Attention shifting to social and non-social cues in high-functioning individuals with autism spectrum disorders.

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Attention Shifting to Social and Non-Social Cues in High-Functioning Individuals with Autism Spectrum Disorders by Joanne Neely

ABSTRACT

Impairments in attention shifting and inhibitory mechanisms have been implicated as possible deficits underlying the behavioural symptomatology of autism. These hypotheses were explored in the first experimental chapter using variations of Posner's covert attention task. No pervasive deficits were found on the attention shifting tasks in either the voluntary or automatic modes. Furthermore, the inhibitory mechanism 'inhibition of return' appeared to be intact. To extend this investigation of visual attentional abilities in autism, two visual search tasks were employed. The pattern of results did not indicate attentional dysfunction. The remaining experiments sought to resolve criticisms such as lack of ecological validity and social significance aimed at contemporary attention research by examining 'social orienting' in autism. Modifications of Posner's cueing paradigm were again used whereby the directional cues were a photographed face with the gaze direction or head orientation manipulated. The pattern of results indicated that individuals with autism oriented attention in a reflexive manner to the direction of eye gaze, however they were less efficient at moving attention at will contingent upon these cues. They had no difficulty moving attention contingent upon the head direction of another. An interference paradigm was used to investigate the relative importance of eye gaze versus head orientation in the analysis of social attention among individuals with autism. While the results do not resolve this dispute, they provide further evidence that individuals with autism have difficulty in using information from the eyes. The final experimental chapter studies accuracy at perceiving frontal eye gaze using a forced choice detection task. No impairments were found. Overall, the results suggest that individuals with autism are not globally impaired in orienting to all social cues, however using information derived from the eyes is problematic and this impairment may be contributing to their difficulties during social interactions.

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Declaration

None of the material contained in the thesis has previously been submitted for a degree in this or any other university.

Statement of copyright

Addendum

The results reported in Chapter 3 have been submitted for publication to Autism: The International Journal of Research and Practice. The manuscript is entitled ' Inhibition and Covert Attention Shifting in High-Functioning Individuals with Autism Spectrum Disorders.'

The results reported in Chapter 4 have been submitted for publication to The Journal of Autism and Developmental Disorders. The manuscript is entitled 'Visual Search Performance in High-Functioning Individuals with Autism Spectrum Disorders.'

The results reported in Chapter 6 have been submitted for publication to The Journal of Child Psychology and Psychiatry. The manuscript is entitled 'Attention Shifting to Social Cues in High-Functioning Individuals with Autism.'

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CHAPTER 1

Autism: An overview

1.1 INTRODUCTION

Since the first published account of autism (Kanner, 1943) over fifty years ago, much effort has been expended into trying to understand why or how autism occurs. However, further empirical work is still required to find the root cause of this puzzling disorder. In generating a better understanding of autism, Morton and Frith (1994) have suggested that three levels of explanation are particularly useful in the study of autism; the behavioural, the biological and the cognitive and it is on the basis of this framework that this chapter progresses. The chapter begins with a review of autism at the behavioural level, as currently a diagnosis is made on the co-occurrence of certain behavioural features. The general consensus is that in all children with autism there is some (perhaps very subtle) brain damage or dysfunction (Steffenburg & Gillberg, 1986; Steffenburg, 1991). The evidence for an organic basis to autism is considered in the next section. While this research has aided our understanding of the biological nature of autism, evidence relating the site of brain abnormality involved in the symptomatology of autism remains inconclusive. However, psychological research into the cognitive mechanisms underlying the specific pattern of behaviours seen in autism has aided our understanding of what functions are impaired in the autistic mind. Ultimately the brain and the mind are inseparable, therefore the challenge for research into autism lies in relating a somewhat disparate set of symptoms to corresponding deficits in brain systems.

1.2 AUTISM AT THE BEHAVIOURAL LEVEL

Autism is a behavioural syndrome and is defined on the basis of impairments in three key domains. These include:

1. social relationships and social development;
2. communication and language and
3. interests and activities that are restrictive and repetitive rather than flexible and imaginative.

This set of three key behaviours has become known as Wing's Triad of impairments (Wing, 1976) and is the basis for the diagnosis of autism today (Rutter & Schopler, 1987). These three impairments in behaviour must occur together and must be present by 36 months of age before a diagnosis can be made (World Health Organisations System for classifying medical disorders, ICD-10, 1990; American Psychiatric Association DSM-IV, 1994). A reliable diagnosis of autism is rarely made before the age of 3 or 4 as the types of behaviours which are impaired do not emerge reliably in typically developing children until this age. Armed with the hope that early diagnosis would enable prompt intervention and thus more effective remediation has led to the search for early indicators of autism. Based on current theories of the behavioural and cognitive characteristics of autism, Baron-Cohen et al., (1996) have developed a screening instrument called the Checklist for Autism in Toddlers (CHAT) and has had some success in pinpointing children as young as 18 months.

1.2.1 Social Behaviour

Kanner (1943) concluded that there is no single social impairment in autism but rather a range of problems is found, some of which can improve during development into adulthood. Children with autism are often unresponsive to people, apparently treating them as objects. They typically avoid eye contact or use eye contact inappropriately and often do

not respond when called by name. They show a lack of behaviour appropriate to cultural norms and seem to be unaware of the feelings of others. However, while some children with autism avoid social contact, not all are 'in a world of their own'. Some do spontaneously approach people but often only to carry out some repetitive, idiosyncratic preoccupation such as touching another person's clothes or hair. They may ask a limited set of questions which are frequently inappropriate to the situation and are rarely about people's feelings or thoughts. The observed variability in social impairments has led to the opinion that there is a spectrum of disorders in autism (Wing, 1988).

1.2.2 Language and Communication

Typically developing children use many different types of communicative behaviour prior to developing language. These include pointing, showing and giving objects to other people in order to communicate their interest in the object (Scaife & Bruner, 1975; Butterworth & Jarrett, 1991; Corkum & Moore, 1995). Children with autism rarely show this type of pointing ('protodeclarative' pointing) or showing (Loveland & Landry, 1986: Landry & Loveland, 1988: Mundy, Sigman, Ungerer & Sherman, 1986: Sigman, Mundy, Ungerer & Sherman, 1986). Typically developing children also use gestures to accompany speech and to express emotions, enhancing these with appropriate eye contact and facial expression. The facial expressions of children with autism often do not match their intonation and many do not develop any useful speech at all. In those children who do develop speech a variety of unusual features may be seen, including echolalia and a difficulty with the use of pronouns. Children with autism frequently use 'you' when they mean 'I' or they may call themselves by their first name.

1.2.3 Repetitive, Obsessional Behaviour

The behaviour of children with autism is distinguished by the absence of flexible and creative pretend play (Wulff, 1985). The repetitive quality in the interests of children with

autism makes their play seem rigid and rehearsed rather than spontaneous and imaginative. They can also become fascinated by a special interest that dominates their time and conversation which can sometimes be on bizarre topics such as counting lampposts, collecting bottle tops and remembering bus timetables. Many individuals with autism show motor stereotypies such as rocking, toe walking, hand flapping, or flicking their fingers rapidly in front of their eyes (Donnellan, Anderson & Mesaros, 1984). Kanner (1943) also noted their 'desire for the preservation of sameness', which can range from the compulsive execution of elaborate routines, to the arrangement of objects which 'must not be altered'.

1.2.4 Asperger's syndrome

At around the same time as Kanner published his paper describing a group of children with autism, Hans Asperger, a Viennese paediatrician, unaware of Kanner's earlier report, published a dissertation on the topic of autistic psychopathy in childhood. Both authors described a similar pattern of symptoms and used the same term. The main area of disagreement between the two descriptions was in the area of language ability with Asperger's case study patients showing no specific difficulties or delay. Unfortunately, Hans Asperger's description was largely ignored in Europe and the United States for the next thirty years until Wing's (1981) important literature review and case series. Lorna Wing was concerned that some children had the classic autistic features when very young, but developed fluent speech and a desire to socialise with others. They did not fit the profile for a diagnosis of classic autism according to criteria based on Kanner's work, however they still had significant problems with more advanced social skills and conversation. They more accurately resembled the original description by Hans Asperger. At present the prevailing view is that Asperger's syndrome is a variant of autism and a Pervasive Developmental Disorder and the condition has now been included in DSM-IV and ICD-10.

While it has been recognised that there are clear differences between children with Asperger's syndrome and autism, as originally defined by Leo Kanner, on measures of social interaction, language and long-term development (Szatmari, Archer, Fisman, Streiner & Wilson, 1995), one area of contention surrounds the possible differences between Asperger's syndrome and High-Functioning Autism. It is well recognised that some children have the classic features of autism in early childhood, but later develop the ability to talk using complex sentences and develop some basic social skills (Wing, 1981). Also, these children usually have an intellectual capacity within the normal range. This group would be described as having high-functioning autism. The continuity of Asperger's syndrome with autism remains the topic of debate (Klin, Volkmar, Sparrow, Cicchetti & Rourke, 1995; Ozonoff, Rogers & Pennington, 1991;Manjiviona & Prior, 1995). The lack, until very recently, of official guidelines for diagnosis has contributed to difficulties in interpreting available research. In addition, a clinical diagnosis of high-functioning autism as opposed to Asperger's syndrome is often made on the basis of access to services. However at present the results suggest there seems to be no meaningful differences between them. There are more similarities than differences.[1]

1.3 AUTISM AT THE BIOLOGICAL LEVEL

During the 1960s, one popular held belief was that autism was a consequence of poor parenting, abuse or neglect (Bettelheim, 1967). Such a view is often referred to as the psychogenic theory of autism, which has now been discredited due to lack of supporting evidence. In contrast, the biological theory of autism continues to receive support from various sources. There are a number of indications that lead to the conclusion that some

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[1] In the experimental chapters reported in this thesis the participants are described as being diagnosed as Autism Spectrum Disorders (ASD) and the prevalence of Asperger's syndrome and high-functioning autism is identified. However, elsewhere in the thesis the term 'autism' is used for brevity.

biological abnormality is at the root of autism. These include the fact that autism is often accompanied by mental handicap (Smalley, Asarnow & Spence, 1988). About three-quarters of all individuals with autism have an associated mental handicap (IQ below 70) and when individuals further down the IQ scale are investigated, the incidence of autism increases (Smalley et al., 1988). Also, there is a high incidence of certain medical conditions such as epilepsy in individuals with autism (Olsson, Steffenburg & Gillberg, 1988; Volkmar & Nelson, 1990).

Secondly, there is increasing evidence of a hereditary component in autism (Rutter et al., 1990). The fact that autism is more than twice as common in males as in females is indicative of a genetic influence (Lotter, 1966; Lord & Schopler, 1987). Family history case reports are also supportive of a genetic role in autism (Gillberg, 1989, 1991; Gillberg, Gillberg & Steffenburg, 1992). Indeed, siblings who are not themselves autistic show a much increased incidence of more general psychological difficulties such as language disorders and social impairments (August, Stewart & Tsai, 1981; Bolton & Rutter, 1990). Monozygotic (identical) twins also have a far higher concordance for autism than dizygotic (fraternal) twins (Folstein & Rutter, 1977). However, the concordance is not perfect which suggests that there may be a genetic predisposition for autism, which only manifests itself if certain pre, peri, or postnatal conditions are met (Goodman, 1990).

Autism also occurs in a number of medical conditions which have a known genetic component, such as Fragile X syndrome, phenylketonuria and tuberous sclerosis (Gillberg & Forsell, 1984; Blomquist et al., 1985; Gillberg, Gillberg & Ahlsen, 1994; Gillberg & Wahlstrom, 1985). Finally, the results of studies using a range of neuropsychological tests and brain imaging techniques and post-mortem studies have revealed abnormalities in different regions of the brain although no specific abnormality has been found to underlie

all cases of autism. Candidate brain areas involved in autism are reviewed in more detail in section 1.4.2 (p12-13) and section 1.4.4 (p22-23).

1.4 PSYCHOLOGICAL THEORIES OF AUTISM

Decades of research following Kanner's (1943) original description of autism have generated a number of psychological theories regarding the nature of the primary deficit underlying the disorder. Contenders have included impairments in mental state processing ('theory of mind') (Baron-Cohen, Leslie & Frith, 1985), a weak drive for 'central coherence' (Frith, 1989: Happé, 1994) and impairments in 'executive function' (Ozonoff, Pennington & Rogers, 1991), among others. A brief review of these three main psychological theories of autism will highlight current controversies and some of their inadequacies and point to possible links with an attention shifting impairment hypothesis of autism (Courchesne, Lincoln, Kilman & Galambos, 1985; Dawson & Lewy, 1989), which will be reviewed in Chapter 2.

1.4.1 Mindblindness

Baron-Cohen, Leslie and Frith (1985) have argued that the triad of behavioural impairments in autism are the result of a deficit in the fundamental human ability to 'mind-read'. They suggest that autism results from damage to an innate theory of mind (ToM) module, which underlies the "mind reading" abilities of normal subjects. This module contains an implicit theory of the structure and functioning of the human mind, which is accessed whenever a normal subject ascribes a mental state to another or seeks a mentalistic explanation of their behaviour. Typically developing children, from around the age of 4 years, understand that people have beliefs and desires about the world and it is these beliefs which determine a person's behaviour. The 'theory of mind' explanation of

autism suggests that individuals with autism lack this ability to think about thoughts and so are impaired in social, communication and imaginative skills.

This ability to impute mental states to the self and others is commonly tested by asking the child to predict the behaviour of others who hold a false belief about the world. Baron-Cohen et al. (1985) showed that 80% of autistic subjects failed to attribute a false belief to a character in an acted out story (the now-classic Sally-Ann task, a simple version of a false belief task devised by Wimmer & Perner (1983)). In contrast, 80% of mentally handicapped and normal 4-year-old subjects were able to predict the character's behaviour on the basis of the inferred false belief.

Critics of these studies have suggested that individuals with autism fail false belief tasks because of pragmatic difficulties (Eisenmajer & Prior, 1991) or lack of motivation to deceive (DeGelder, 1987). However, people with autism have been shown to fail a wide range of false belief tasks such as the 'smarties task' (Perner, Frith, Leslie & Leekam, 1989). Moreover, these findings have now been replicated in a number of studies, using real people instead of toys, slight changes in the wording - using 'think' rather than 'look' and using a control group of language-impaired children to rule out a language processing deficit (Leslie & Frith, 1988), suggesting that pragmatic difficulties are not contributing to their failure on these tasks. Furthermore, motivation to deceive was assessed by Sodian and Frith (1992) in a study which showed that children with autism were able to use sabotage to prevent another person from obtaining a goal, however they could not use deception for this purpose.

Although several authors would accept that autistic individuals fail on false belief tasks due to an inability to mentalize, they do not accept that this is the core psychological impairment in autism. The fact that 20% pass a false belief task and still be socially handicapped poses a problem for the theory. Indeed, Bowler (1992) found that in groups of

subjects selected for normal verbal IQ the success rate on ToM tasks is much higher. In this study the performance of a sample of fifteen high-functioning adults with autism was compared to that of normal controls and schizophrenic adults on false belief tasks at two levels of difficulty. The results showed that the individuals with autism were no worse on these tasks than either of the comparison groups, with autistic subjects passing second-order false belief tasks (the ability to think about another person's thoughts about a third person's thoughts about an objective event). Bowler suggests that the handicap experienced by individuals with autism with real life social situations stems from a deficit in applying existing knowledge and not from a difficulty with mentalizing. He suggests that the good task performance of the subjects in his study is based on different mechanisms than normal mentalizing: " although people with Asperger's syndrome can compute correct solutions to problems requiring a theory of mind, they do so by routes that are slow and cumbersome, disrupting the timing of their responses and making them appear odd in everyday social interactions" (Bowler, 1992).

This account is similar to one proposed by Frith, Morton and Leslie (1991) who suggest that the success of the individuals with autism should be seen not as proof of TOM ability but rather as evidence of some other strategy they have developed for solving the tasks. To test these possibilities Happé (1994) posed a more naturalistic challenge to subjects in the form of 'strange stories'. The stories revealed impairments in social understanding in even the most able individuals with autism who had passed all the tasks in the first and second order ToM battery. This may be because these 'strange stories' are only understood using an advanced theory of mind level (e.g. double bluff). Another possibility may be the more naturalistic format of the stories and the fact that the questions posed do not draw attention to the salient features of the task.

Further argument against the primacy of an inability to mentalize being the underlying psychological impairment in autism has arisen because of evidence that children with autism show earlier social-cognitive deficits, such as lack of imitation (Rogers & Pennington, 1991) and joint attention behaviours (Sigman, Mundy, Sherman & Ungerer, 1986; Baron-Cohen, 1989b; Loveland & Landry, 1986). During normal human development, joint attention is a critical milestone along the road to complex social and language abilities and normally appears by 12 to 15 months of age (Trevarthen & Hubley, 1978; Bakeman & Adamson, 1984).

Joint attention is often described as the triadic relationship between self, other and object and is thought to be a precursor to the development of a 'theory of mind' (Baron-Cohen, 1995; Leslie, 1987). Baron-Cohen (1995) now proposes that 'theory of mind' shortcomings in autism may be secondary to an earlier emerging impairment in the ability to build 'triadic representations'. Baron-Cohen suggests that the brain contains specialised modules dedicated to social perception and action. One such module deemed to be intact in individuals with autism is an 'eye direction detector', used to identify the direction of gaze and any direct eye contact. This in turn feeds information to a 'shared attention mechanism' which is necessary to understand whether the self and another agent are both attending to the same object or event, a mechanism which is suggested to be deficient in children with autism (Baron-Cohen, 1994; 1995).

An alternative position to the progression of joint attention behaviours requiring triadic relationships is the opinion that joint attention is linked with developments in attention (Leekam, Lopez & Moore, 2000). Research with typically developing infants shows that the visual orienting mechanisms undergo substantial development in the first year of life, shifting from subcortical visual processing to processing in cortical visual pathways (Bronson, 1982; Atkinson, 1984; Johnson, 1990). For example newborns much

more readily orient towards stimuli in the temporal, as opposed to the nasal visual field (Lewis, Maurer & Milewski, 1979). Also at around one month of age infants show 'obligatory attention' (Johnson, Posner & Rothbart, 1991; Hood, 1995). That is to say they have great difficulty in disengaging their gaze away from a stimulus in order to make a saccade to another location. Progress in the endogenous or voluntary control over shifts of attention and saccades proceeds around 4 to 6 months (Johnson, 1995). Based on the results from a series of experiments with preschool children with autism, Leekam et al. (2000) suggest that children with autism do not have difficulty making exogenous or stimulus driven shifts of attention; however there may be a developmental delay in their endogenous control.

Voluntary control of attention and development of theory of mind

In normal development, social knowledge and many higher cognitive, affective and communicative functions arise from early infant-mother interactions (Trevarthen & Hubley, 1978; Bakeman & Adamson, 1984). The control and ability to shift attention efficiently is of fundamental importance during any normal joint interchange because the focus of information (gestures, sounds, objects, expressions etc) is changing frequently, rapidly and often unpredictably. Scaife and Bruner (1975) showed that typically developing infants as young as two months would readjust their gaze contingent on a change of focus of attention of an adult, however it is not until towards the end of the first year that infants normally achieve the skill of coordinating their attention between a social partner and objects of mutual interest (Butterworth & Jarrett, 1980; Corkum & Moore, 1995). At around this time, looking where others point is also observed in most babies (Butterworth & Grover, 1990; Deak, Flom, Pick & Silberglitt, 1997). To achieve this major developmental milestone, an infant needs to do more than simply focus his or her attention on a single captivating character of an object or person. He/she must follow the

rapid and unpredictable ebb and flow of human social activity, such as words, gestures, facial expressions and actions. These activities provide signals to the infant to shift attention in order to follow the varying sources of social, emotional and circumstantial information. The ability to smoothly, effectively and rapidly shift attention enables the infant to combine, as a single entity in memory the various and separate components of a social situation. Clearly any damage or delay to this voluntary attentional regulatory system could produce severe developmental abnormality, perhaps resulting in the particular socio-cognitive functioning typical of autism.

1.4.2 Biological basis for mind-reading ability

Several attempts have been made to outline the brain regions involved in theory of mind. The frontal lobes have long been considered to play a special role in human behaviour, with damage to this region affecting not only high level cognitive functions but also social behaviour (Ackerly & Benton, 1947; Brazzelli, Colombo, Della Sala & Spinnler, 1994; Prigatano, 1991). While these reports are suggestive of this area being important in making mental state attributions, only a small number of studies have investigated this directly. Two studies have found frontal lesions to be associated with impairments on theory of mind type tasks (Stone, Baron-Cohen & Knight, 1998; Channon & Crawford, 2000). Stone et al. (1998) have reported that patients with inferior medial damage but not left dorsolateral pathology were impaired on theory of mind tasks. Channon and Crawford (2000) report findings that left frontal lesions are associated with deficits on theory of mind type tasks. More recently, Stuss, Gallup and Alexander (2001) have reported a dissociation of performance on tasks requiring a theory of mind within the frontal lobes. These authors studied patients with well-defined focal and limited brain lesions in frontal and non-frontal regions to assess which regions were necessary for mental state attribution. Two tasks were employed: a transfer inference task and a deception task. The results

showed that bi-frontal lesions, which predominantly involved medial regions, impaired performance on the deception task. There was less specificity of lesion location within the frontal lobes for the transfer inference task, although there was some suggestion for a greater role for the right frontal region.

Functional imaging data also suggests a role for the frontal lobes in theory of mind. Fletcher et al. (1995) studied story comprehension using PET (positron emission tomography) brain imaging in healthy typically developing participants and reported left medial frontal gyrus activation on stories that involved the attribution of mental states to the main characters, but not on stories which involved only physical states. Goel, Grafman, Sadato and Hallett (1995) compared healthy volunteers on several tasks involving object knowledge and reported left medial frontal and left temporal activation only in the theory of mind type condition. Baron-Cohen et al. (1994) reported increased right orbitofrontal activation in a SPECT (single photon emission computed tomography) study during a task in which subjects had to decide which aurally presented words ' described the mind or things the mind can do'. He has suggested a neural circuit including the amygdala, superior temporal sulcus and orbitofrontal cortex as regions necessary for mental state attribution. Recent support for this view comes from a single case study of a patient with early or congenital amygdala damage who was found to be severely impaired in his ability to represent mental states (Fine, Lumsden & Blair, 2001).

An alternative view of the neural circuitry for theory of mind processing has been proposed by Frith and Frith (1999). They argue that this circuitry comprises the superior temporal sulcus, the inferior frontal regions and the medial prefrontal cortex. Convergent with this proposal, activity in the medial prefrontal cortex and the region of the temporoparietal junction has been observed in neuroimaging studies during mental state processing (Castelli, Happé, Frith & Frith, 2000; Gallagher et al., 2000). Thus, although

frontal areas have been implicated in several studies, the precise neural circuitry remains to be established.

1.4.3 Central Coherence Theory

Although the 'Mindblindness theory' has helped us to understand the nature of the autistic child's handicap in communication, socialisation and imagination, there are other features of autism in addition to the classic triad of impairments. Parental reports on the development of children with autism (Hart 1989; McDonnell, 1993) supported by clinical observations (Kanner, 1943) have highlighted a number of aspects of autism not well explained by a lack of mentalizing. These include a restricted repertoire of interests, a preoccupation with parts of objects (diagnostic criteria in DSM-IV, American Psychiatric Association, 1987), an obsessive desire for sameness (Kanner, 1943), islets of ability (Kanner, 1943), excellent rote memory (Kanner, 1943) and idiot savant abilities (1 in 10 autistic children, Rimland, 1978). In addition, a number of experimental studies have reported surprising advantages and disadvantages shown by individuals with autism on a wide range of cognitive tasks (Hermelin & O'Connor, 1967: Frith & Hermelin, 1969; Weeks & Hobson, 1987; Langdell, 1978). Influenced by the notion of one primary deficit being the underlying cause of both the assets and deficits seen in autism led Frith (1989) to propose that autism is characterised by a particular cognitive style whereby the normal tendency to draw diverse information together to construct higher-level meaning in context is lacking. Contrary to normal information processing where extracting 'global' meaning is paramount, individuals with autism focus on 'local' details without integrating them into a coherent whole.

Evidence for local processing ability in autism

Individuals with autism show an unusually 'spiky' profile across Wechsler Intelligence Scales (Wechsler, 1981) subtests, showing for example, superior performance on the block

design task relative to other subtests, and often relative to other people of the same age. This fact has generally been explained as due to superior spatial skills (Lockyer & Rutter, 1970; Prior, 1979), however the designs in these tasks are notable for their strong gestalt qualities. The reason typically developing people appear to have difficulty with this task is the effortful process involved in inhibiting the overall picture and breaking it up into constituent parts. Central coherence theory (Frith, 1989) implies that the advantage shown by subjects with autism on tasks like the block design is due to their inability to integrate perceptual information. Individuals with autism are said to experience a fragmented perceptual input, which is characterised by local, rather than global processing. They seem to focus on the insignificant details of the environment without integrating them into the wider context.

Additional evidence in support of this theory comes from Happé (1996), who reports that children with autism do not succumb to visual illusions. Both two-dimensional and three-dimensional illusions were employed in this study. Results from the three-dimensional condition suggest that the success of the autistic subjects on this task was due to their inability to integrate the induced lines from the inducing context. When the induced lines were disembedded from the inducing context (as in the three-dimensional condition), the group differences disappeared. This finding is similar to Shah and Frith's (1993) study with the block design task, where pre-segmenting the designs brought the control performance to the level of the autistic group's success, but did not improve performance among the subjects with autism.

Further evidence that subjects with autism have a tendency to process local rather than global information is seen in their superior performance with the spotting 'embedded figures' task (Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983). This test involves spotting a hidden figure (triangle or house shape) among a larger meaningful drawing.

Subjects with autism show a faster and more accurate performance on this task compared to matched control groups. Gottschaldt (1926) attributes the difficulty of finding embedded figures in normal subjects to the overwhelming 'predominance of the whole'.

Global processing deficits

Focusing on detail or a lack of central coherence would be expected to produce disadvantages on tasks that require interpretation of stimuli in terms of overall context and there is some evidence to support this prediction. Individuals with autism show a failure to process incoming stimuli in context during reading which results in a superior rote memory for sentences but little knowledge or understanding of the meaning of the material (Frith & Snowling, 1983). Similarly, Happé (1997) has reported that individuals with autism show an inability to use context to disambiguate linguistic material in a homograph-reading task. Moreover in the 'strange stories' task (Happé, 1994a) subjects with autism often gave context-inappropriate answers suggesting they were focusing on the utterances in isolation, prompted by a specific question and not relating it to the context of the story.

Central coherence and attention

There is a growing body of evidence reporting superior local processing skills among individuals with autism and some reports of a bias in adopting a local processing strategy during tasks requiring global processing. It is possible that an attentional impairment could account for the tendency of individuals with autism to adopt this particular cognitive style. Frith (1989) noted that typically developing individuals 'draw together diverse information to construct higher-level meaning in context.' It is possible that this 'effort after meaning' is lacking in individuals with autism as the result of an inability to shift attention rapidly and efficiently. This would result in a fragmented perceptual input as the details and movements of scenes change.

Central coherence and mentalizing

In the original 'central coherence theory' Frith (1989) proposed that the impairment in mentalizing ability seen in individuals with autism could be a result of 'weak central coherence'. Clearly an inability to integrate information from many sources would limit understanding of social interactions and the ability to attribute mental states. More recently, however, Frith and Happé (1994) have suggested that these two cognitive features of autism may be separate. They reason that, while the ability to attribute mental states would appear to be of great evolutionary advantage and is acquired at the same age across cultures with little variation (Avis & Harris, 1991), processing information in context and the precedence normal individuals give to global processing may vary in the population as indexed by inter-individual differences in scores on the Block Design or Embedded Figures test. They regard a weak central coherence as a particular cognitive style rather than a deficit and in this respect individuals with autism may be at the extreme end of a normal continuum.

In support of the opinion that there are two separate cognitive mechanisms underlying autistic symtomatology, Happé (1997) showed that individuals with autism at all levels of theory of mind performance still displayed a relative failure to process information for context-dependent meaning in a homograph reading task.

1.4.4 Executive Dysfunction

Recognising the need to explain that some high-functioning autistic subjects can pass theory of mind tasks yet still exhibit some autistic behaviours has led researchers to speculate an alternative or additional cognitive impairment. The first indication of executive function deficits in autism came from a single case study of an adult with residual state autism (Steel, Gorman & Flexman, 1984). Executive function is defined as the ability to maintain an appropriate problem solving set for attainment of a future goal

(Bianchi, 1922: Luria, 1966; Goldstein, 1936, 1944) and is associated with the frontal lobes (Gorenstein, Mammato & Sandy, 1989; Hebb, 1939, 1945; Marlow, 1989; Milner, 1964). Typical manifestations of executive function include set-shifting and set maintenance, interference control, inhibition, integration across space and time, planning and working memory. Typical tests of executive function thought to be markers for frontal lobe functioning include the Wisconsin Card Sorting Test (WCST), the Tower of Hanoi, the closely related Tower of London, the Matching Familiar Figures Test (MFFT), and the Stroop Colour-Word Test among others.

The most frequently used executive function measure used in studies with individuals with autism has been the WCST. This test involves deducing a rule that periodically changes, for sorting cards by either colour, shape or number, using feedback from the examiner concerning the correctness of each sort. The primary variable of interest is the number of perseverative responses, defined as the number of trials in which the subject continues sorting by a previously correct category despite negative feedback (Heaton, 1981). In the main, studies have found that individuals with autism perform poorly on this task relative to matched controls, with deficits evident as perseveration and difficulty shifting sorting category (Rumsey, 1985; Rumsey & Hamburger, 1988, 1990; Prior & Hoffman, 1990; Ozonoff, Pennington & Rogers, 1991; Ozonoff & McEvoy, 1994). However Schneider and Asarnow (1987) found no group differences in perseveration on the WCST. They studied school-aged children with autism, comparing them to children with schizophrenia and normal controls. Interpretation of the results is problematic because all subjects perseverating throughout the task were eliminated from the analyses. In addition, the groups were not matched on ability. A second study though has failed to find group differences in a WCST task (Minshew, Goldstein, Muenz & Payton, 1992), with no obvious methodological problems.

Although the bulk of research would suggest that individuals with autism suffer from an executive dysfunction there are at least three issues that cause problems for the theory that an executive function impairment underlies autistic symtomatology (Harris, 1993; Ozonoff, 1995; Pennington, 1994). These include:

1. The multidimensional nature of executive function tasks.
2. Autism is not the only disorder in which executive functions are impaired.
3. The lack of evidence implicating frontal lobe pathology in autism.

The multidimensional nature of executive function tasks

Firstly, executive function tasks tap far more than one cognitive operation; therefore it is difficult to determine why individuals with autism perform poorly on any of these tasks. For example, the Stroop test has been described as measuring inhibition, sensitivity to interference, selective attention and focused attention (Mirsky, Anthony, Duncan, Ahearn & Kellam, 1991). Two studies have found the Stroop effect to be similar in individuals with autism and a control sample (Bryson, 1983; Eskes, Bryson & McCormick, 1990). Whilst this might suggest that these aspects of executive function relatively spared in individuals with autism, some of these components are also involved in other types of executive function tasks where individuals with autism perform poorly compared to matched controls. While the WCST is generally considered a test of cognitive flexibility, successful performance requires a variety of other cognitive operations. These include generating of a sorting rule, categorization, working memory, attention to and encoding of the examiner's verbal feedback, in addition to inhibition and selective attention to the relevant dimensions of the stimuli (Ozonoff, 1995). Moreover, while the MFFT requires the inhibition of impulsive responses, visual pattern analysis and attention to detail are also important for competent performance. Because of difficulties interpreting precisely why individuals with autism show performance deficits on some of these tasks, a number of

studies have been designed to dissect the executive function deficit in autism using information processing paradigms.

Componential approach to executive function deficits

Ozonoff, Strayer, McMahon and Filloux (1994) compared non-retarded autistic individuals to Tourette's syndrome individuals and normal controls on several simple inhibition tasks. The Go-NoGo task consisted of three test conditions. The first 'neutral inhibition' condition required subjects to respond to a neutral stimulus, while inhibiting responses to another neutral stimulus; this condition required no shifting of cognitive set. The second 'prepotent inhibition' condition required inhibition of a previously reinforced well-learned response. The third 'flexibility' condition required subjects to frequently shift from one response pattern to another. The sample with autism was significantly impaired on cognitive flexibility. Predictions regarding the absence of group differences in the neutral inhibition were supported. However their hypotheses about performance in the prepotent inhibition condition were not fully confirmed. Although performance during this condition was slower than the neutral inhibition, the specific pattern of responses predicted was not revealed. They argue that while the Go-NoGo task may have been able to differentiate neutral inhibition from flexibility, two cognitive operations often confounded in EF tasks, the constructs of 'pre-potent inhibition' and 'flexibility' are more difficult to separate, both operations requiring shifts between response sets to varying degrees. Thus, this paradigm did not selectively measure inhibition as intended.

In a later study by Ozonoff and Strayer (1997), two information-processing paradigms were selected to focus on specific inhibitory cognitive processes, which are not confounded with flexibility operations. These were the Stop-Signal paradigm (Logan, 1994; Logan, Cowan & Davis, 1984) and a negative priming task (Tipper, 1985). The Stop-Signal paradigm is thought to measure the ability to control a voluntary motor

response, whereas the negative priming task taps a more central, cognitive inhibitory mechanism (Neill, Lissner & Beck, 1990). Ozonoff and Strayer (1997) found that subjects with autism were unimpaired on both tests of inhibition relative to normally developing controls. Thus it would seem that inhibitory mechanisms are not contributing to the executive function impairments seen in individuals with autism. However not all aspects of inhibition have been investigated and these studies only explored inhibitory function in non-retarded children with autism. It may be possible that lower functioning individuals with autism could demonstrate impairments on simple inhibition tasks.

Hughes, Russell and Robbins (1994) have also employed an information processing approach to determine the underlying cognitive operations that contribute to impaired performance on the WCST. These authors used the Intradimensional-Extradimensional (ID/ED) Shift task to assess set-shifting ability in individuals with autism. This task requires subjects to classify abstract patterns according to an initially unknown rule and then to shift to a new rule after the previous sorting pattern receives negative feedback. While this task appears very similar to the WCST, it does not require verbal ability or social interaction as the computer provides both stimuli and feedback. In addition, the task is completed in several stages allowing alternative interpretations of poor performance such as set-maintenance, rule reversal, transfer of learning and motoric inhibition to be excluded. The results showed that the individuals with autism engaged in highly perseverative patterns of responding, displaying an inability to flexibly shift mental set.

The problem of specificity

A second problem for the executive function hypothesis is that autism is not the only disorder in which executive functions are impaired. Significant deficits on EF tasks are manifest in several psychiatric disorders, including Conduct disorder (Hurt & Naglieri, 1992; Lueger & Gill, 1990), Obsessive Compulsive Disorder (Head, Bolton & Hymas,

1989; Martinot et al., 1990) and Schizophrenia (Axelrod, Goldman, Tompkins & Jiron, 1994). Executive function deficits have also been reported among other developmental disorders, such as Turner's syndrome (Romans, Roeltgen Kushner & Ross, 1997), ADHD (Chelune, Ferguson, Koon & Dickey, 1986; Benson, 1991), early treated phenylketonuria (Welsh, Pennington, Ozonoff, Rouse & McCabe, 1990), Fragile X Syndrome (Mazzocco, Hagerman, Cronister-Silverman & Pennington, 1992; Levitas et al., 1983), Tourette Syndrome (Bornstein, 1990) and also among individuals with neurological conditions such as Parkinson's disease (Owen et al., 1995). Obviously, exactly the same executive deficit cannot be the underlying cognitive cause of the varied pattern of symptoms that characterise each of these disorders. This problem of specificity is termed the 'discriminant validity' problem (Ozonoff, 1997).

There are a number of studies that have tried to address this discriminant validity issue. A study by Szatmari, Tuff, Finlayson and Bartolucci (1990) included a comparison group of individuals, 80% of whom met the criteria for either ADHD, conduct disorder or both. As mentioned above, executive function may be associated with these syndromes as well. Despite this choice of control group, subjects with autism still made significantly more perseverative errors and completed fewer categories on the WCST. Similarly, Ozonoff et al. (1991) demonstrated that individuals with autism perseverated on the WCST significantly more than the comparison group, of whom 25% met the criteria of ADHD. These studies would suggest that the WCST is a sensitive indicator of executive dysfunction in individuals with autism, however two investigations have failed to find deficits on this task in autistic samples as mentioned above (Schneider & Asarnow, 1987; Minshew et al., 1992).

Lack of evidence for frontal lobe pathology

A third problem for the executive dysfunction hypothesis of autism is the brain area supposed to be implicated in the successful execution of these tasks, namely the frontal lobes (see Kolb & Wishaw, 1990 for a review). To date, there have been no consistent reports of frontal lobe pathology (see Robbins, 1997 for a review) in autism. Indeed no single abnormality has been found in post mortem brain studies and it is uncertain whether the abnormalities detected are due to autism, rather than to mental handicap or epilepsy. Autopsy studies, usually involving small samples, have provided some evidence of abnormalities in the cerebellum with significant Purkinje cell loss (Ritvo et al., 1986). A single case study (Bauman & Kemper, 1985) of a severely learning disabled autistic man with epilepsy found abnormalities in the hippocampus, amygdala and cerebellum, compared with a normal age-matched control. However, the effects of medication or a lifetime of 'autistic behaviour' (e.g. motor stereotypies) on the brain make these findings difficult to interpret. Courchesne, Hesselink, Jernigan and Young-Courchesne, (1987) and Courchesne et al. (1988) using magnetic resonance imaging (MRI) have found abnormalities in the cerebellar vermis of relatively able individuals with autism. Evidence from studies using computerised axial tomography (CAT) revealed equivocally, increased ventricular dilation (Campbell et al. 1982), which was not replicated in other samples (Creasey et al., 1986).

However, failure on frontal lobe tasks need not indicate damage to the frontal lobes. Moreover, the prefrontal cortices have broadly integrative functions and it is reasonable to presume that deficient inputs from other systems, especially in the case of early and nonfocal brain lesions could disrupt their function. With the advent of novel, non-invasive techniques for the assessment of regional blood flow in the central nervous system consequent upon neural activation and using the knowledge of autism at the

behavioural and cognitive level, it may be possible in future to assess the area of the brain that is abnormal in autism.

Executive function and theory of mind

To resolve the issue of which deficit is the primary core impairment in autism, the relationship between theory of mind and executive functions has become the topic of much debate. One position is that the development of executive function allows the child's theory of mind to develop (Russell, 1997; Ozonoff, 1997). Secondly, it has been argued that there are no specific circuits for processing mental states and that performance on theory of mind tasks can be reduced to executive function ability (Frye, Zelazo & Palfai, 1995). Alternatively, Perner and colleagues (Perner, 1998; Perner & Lang, 2000) have suggested that the capacity to represent mental states is necessary for the development of executive functioning.

At present it is difficult to find definitive support to distinguish between any of these possibilities. A recent study has found that theory of mind and executive function abilities are correlated in pre-school children (Hughes, 1998a). Furthermore, executive function ability predicted theory of mind performance, but not vice versa (Hughes, 1998b). Moreover, Ozonoff et al. (1991) found a correlation between performance on executive function and theory of mind tasks in individuals with autism, but not in the comparison group. Thus, it has been suggested that individuals with autism have difficulty on theory of mind tasks due to their lack of executive control (Russell, 1997). However, theory of mind tasks are likely to involve an executive component (Leslie & Thaiss, 1992), therefore correlations might be expected, especially in populations who do not perform at ceiling on executive function tasks (Fine, Lumsden & Blair, 2001). Associations between these two cognitive abilities might also be expected, given that both abilities are proposed to be mediated by anatomically adjacent or proximal regions of the frontal lobes.

While these studies are unable to resolve the issue of the developmental interaction between theory of mind and executive functions, a recent single case study of a patient with congenital amygdala damage has shown that theory of mind is not simply a function of more general executive functions and that executive functions can develop and function on-line, independently of theory of mind (Fine et al., 2001).

1.5 Possible inadequacies of psychological theories of autism

The challenge to psychological theories of autism is not only to explain the triad of impairments but also to explain the islets of unimpaired or even superior skills in autism. Traditionally authors have focused on one core psychological impairment to account for the behavioural manifestations found in autism. However, it has been recognised that a disorder as complex and severe as autism is unlikely to be the result of one primary deficit and indeed it may be more fruitful to consider autism a disorder of multiple aetiology (Goodman, 1989). From the studies reviewed above, it can be seen that each psychological theory presents problems.

Mindblindness

For example, how can 'Mindblindness' explain autism if some, still socially handicapped individuals with autism appear to possess a theory of mind (Baron-Cohen et al., 1985). In addition, the 'Mindblindness' theory of autism cannot explain the non-social handicaps in autism, such as insistence on sameness, repetitive behaviour and stereotypies. Moreover, earlier appearing social deficits such as joint attention and imitation, thought to be precursors in the development of a 'theory of mind' have been reported. It is difficult to argue that a lack of mentalizing ability is the core psychological impairment in autism if a more basic deficit might underlie the later development of an inability to think about thoughts.

Central Coherence

The central coherence theory differs from other theories, claiming some features of autism to be as a result of a particular cognitive style rather than a straightforward deficit. This plausible hypothesis has enabled many features of autism, often neglected in previous investigations to be accounted for. For example, Kanner (1943) highlighted this tendency for fragmentary processing and its function in the child with autisms' resistance to change: " a situation, a performance, a sentence is not regarded as complete if it is not made up of exactly the same elements that were present at the time the child was first confronted with it". Similarly this account is able to explain some of the assets found in individuals with autism. However the weak central coherence theory of autism is still in its infancy and requires considerable empirical work to be refined and become established.

Executive Dysfunction

The executive function deficit theory of autism has attempted to account for both the social and non-social handicaps. However a good comprehensive theory must encompass deficits that are specific to autism and universally found among individuals with autism and as outlined above this is not true for the executive dysfunction theory of autism. It is also unclear if all executive operations are impaired or only a portion. Moreover, the vague term 'executive function' covers many higher cognitive functions and may encompass aspects of both central coherence and theory of mind.

Possible links with an attention dysfunction theory of autism

Because attention plays an important role in the execution of complex cognitive operations, an attentional deficit in autism might therefore hinder the development of higher order cognitive and social skills such as executive function and theory of mind. For example, it has been suggested that the lack of joint attention behaviours in autism could result in damage or delay in the voluntary control over attentional capabilities (Leekam et

al., 2000). Abnormal attentional processes are highly likely to be associated with difficulties in understanding the meaning of environmental cues, leading to poor choices of what to attend to in the absence of clear directives. In addition, social interactions would be particularly vulnerable to disruption because the focus of information changes rapidly and unpredictably.

The component process approach has attempted to decompose the complex cognitive operations involved in executive function tasks into elementary components, identifying inhibition as relatively spared in individuals with autism, with the ability to flexible shift mental set relatively impaired. However, it could be argued that an inability to flexibly shift mental set could be further decomposed into more basic attentional processes such as deficits in attention shifting (Courchesne et al., 1985) or difficulties disengaging from a salient object (Hughes & Russell, 1993). Moreover, the tendency to focus attention on local attributes of a stimulus without integrating them into a coherent whole seen in autism could also be the result of an attention shifting impairment.

Attention underlies the more complex skills featured in the three main theories and points to the fact that this may be the source of their difficulty. The proposal that an attentional dysfunction may underlie the symptomatology of autism is reviewed in more detail in Chapter 2.

CHAPTER 2

Investigating attention: An overview

2.1 INTRODUCTION

This purpose of this chapter is to review the evidence for impairments in visual attention in individuals with autism. The chapter begins with a consideration of the behavioural evidence that attention is unusual in autism. Then follows a brief review of Courchesne's neuropsychological theory of autism which has proposed that an attentional impairment related to cerebellar pathology may underlie the behavioural manifestations in autism (Courchesne et al., 1985). Before a more detailed consideration of the empirical evidence for attentional impairments in autism some of the key ways that attention has been studied in typically developing individuals is considered. The chapter concludes with the aims of the thesis.

2.2 BEHAVIOURAL EVIDENCE FOR ATTENTIONAL DYSFUNCTION IN AUTISM

There is considerable evidence in the literature to suggest that children with autism attend to their environments in unusual ways. Kanner's (1943) original description of the disorder emphasised " the inability to experience wholes without full attention to the constituent parts" (p.38). Reports by clinicians, teachers and parents also confirm abnormal attentional focus (Hayes, 1987). In many instances children with autism appear oblivious to other people and often become fascinated with certain objects - a fascination that can lead to overly focused attention to the exclusion of the rest of the world. Indeed, the very first published account of an autistic child stated that the child displayed " an abstraction of mind which made him perfectly oblivious to everything about him..... and that to get his

attention almost requires one to break down a mental barrier between his inner consciousness and the outside world" (Kanner, 1943, p218). Hypo- and hypersensitivity to sound, touch, smell and vision are described (Grandin, 1992; Williams, 1994; Stehli, 1991) as well as intense experience of normally unnoticed aspects of the environment. This becomes evident in their obsessive desire for sameness. Children with autism can become extremely upset by changes of routine or surroundings, placated only when the familiar order is restored (Turner, 1997). These relatively casual observations of abnormal attentional control in autism lead on to the work based on contemporary attention theory which will be reviewed in section 2.4 and 2.5

2.3 ATTENTION DYSFUNCTION-NEUROPSYCHOLOGICAL THEORY

Courchesne (1991) proposes a neuropsychological theory of autism whereby the cerebellum plays a critical role in the shifting of attention. Courchesne and colleagues (Courchesne, Townsend et al., 1994; Courchesne, Yeung-Courchesne, Press, Hesselink & Jernigam, 1988; Townsend, Courchesne & Egaas, 1996; Townsend et al., 1999) have theorized that the neocerebellum may play a role in the coordination of attention systems that is similar to the role it plays in the control and integration of motor activity (Holmes, 1939; Hallett, Shahani & Young, 1975). The early absence of this neocerebellar coordination in autism would particularly disrupt the processing of sequential information whose significance unfolds over time. Although not specific to the more complex social domain, social interactions would be especially vulnerable to disruption because of their complexity and unpredictability. In addition, Courchesne et al. (1994) propose that there may be a neurodevelopmental "domino effect" in autism, whereby primary abnormalities of the developing cerebellum might lead to further brain abnormalities, which in turn might produce additional functional deficits (Courchesne et al., 1994). In support of this

notion, it has been reported in a number of studies that patients with cerebellar lesions display frontal like symptoms (Bracke-Tolkmitt et al., 1989; Appollonio et al., 1993; Canavan et al., 1994). Moreover, Holroyd, Reiss & Bryan (1991) report autistic features in two children with Joubert Syndrome, a genetic disorder with agenesis of the cerebellar vermis. Also, although the cerebellum has traditionally been viewed as essential for the control and integration of motor activity (Holmes, 1939; Hallett, Shahani & Young, 1975), recent years have seen claims that the cerebellum contributes to higher mental function (Leiner, Leiner & Dow, 1986, 1993; Schmahmann, 1991; Akshoomoff & Courchesne, 1992; Kim, Ugurbil & Strick, 1994; Middleton & Strick, 1994; Canavan, Sprengelmeyer, Deiner & Homberg, 1994; Gao et al., 1996).

However, contemporary attention researchers have not implicated this area in the brain circuitry involved in attention, which will be reviewed in section 2.4. Moreover, contradictory findings have been reported relating impairments in attention shifts with cerebellar abnormalities. Yamaguchi, Tsuchiya and Kobayashi (1998) investigated visuospatial attention shifting and motor responses in patients with cerebellar degenerative disorders and suggest that the cerebellum makes little contribution to visuospatial attention shifting in either the voluntary or automatic modes. Their results support a role of the cerebellum in the neural systems required for response preparation and selection. Similarly, Helmuth, Ivry and Shimizu (1997) found similar attentional cueing effects under both exogenous and endogenous cueing conditions between a group of cerebellar patients and matched controls. However, both studies used groups of patients who had acquired cerebellar disorders as adults. In the Courchesne studies, individuals with autism have generally been used as a model for cerebellar dysfunction bolstered by corresponding studies using adolescents with acquired cerebellar lesions. Conflicting results could be the product of age of onset of cerebellar dysfunction.

There remains a number of provocative results regarding the cerebellum and the behaviours seen in autism. Firstly, in contrast to the specific social deficit seen in autism, individuals with Williams syndrome appear to show almost the opposite neurocognitive profile to autism. Williams syndrome is a rare genetic neurodevelopmental disorder resulting in an uneven linguistic-cognitive profile. For example linguistic skills and face processing are surprisingly preserved despite low IQs (typically 50-60), with serious deficits on visuospatial, number, motor, planning and problem-solving tasks (Karmiloff-Smith et al., 1995). Moreover, while only 20% of individuals with autism pass theory of mind tasks such as those described earlier, 94% of the Williams syndrome subjects passed these tasks. Evidence from structural neuroimaging indicates that Williams syndrome brains show a relative increase in volume in particular lobules on the cerebellum which contrasts with autism in which the same lobules are relatively smaller than normal (Jernigan & Bellugi, 1994). Secondly, as mentioned earlier (p29), a number of studies have linked frontal-like symptoms and autistic features in patients to cerebellar lesions (Bracke-Tolkmitt et al., 1989; Appollonio et al., 1993; Canavan et al., 1994; Holroyd et al., 1991).

Before reviewing the empirical evidence for an attentional dysfunction in autism, two important dichotomies derived from contemporary attention research with typically developing individuals are considered.

2.4 CONTEMPORARY RESEARCH ON VISUAL ATTENTION

Much debate has surrounded the general concept of attention and how it should be defined (Spearman, 1937). Definitions or metaphors such as a filter (Broadbent, 1958), a selective attenuator (Treisman, 1964), a resource (Neisser, 1976), a 'spotlight beam' within which processing is enhanced (Posner, 1980), a 'zoom lens' (Eriksen & Yeh, 1985), a 'glue' that binds features together (Treisman & Gelade, 1980) among others, have added to the

disunity. Moreover, issues such as capacity, selectivity, control, relationship to consciousness and arousal have added further argument.

In recent decades, most attention researchers have chosen to use visual stimuli partly because this allows more precise control over exactly when stimuli are processed and much progress has been made in understanding how attention oriented to locations and/or objects in visual space is controlled. Research by contemporary attention theorists has led to several important distinctions. Two that are relevant to this thesis are the distinction between 'overt' and 'covert' orienting and between issues of control, either voluntary or reflexive/automatic.

2.4.1 Covert orienting of visual attention

Generally visual attention and eye fixation are synonymous. This occurs because the retina of the eye is a heterogeneous structure, containing a foveal area at the centre that provides a small area of high acuity. Overt eye movements are required to bring this foveal area to bear on peripheral objects for detailed form analysis. However, it has been known at least since Helmholtz's time that one can attend to peripheral objects without making an eye movement. Helmholtz (1909) conducted an experiment to test his ability to shift visual attention independently of eye fixation. He fixed his eyes on an illuminated pinhole in the centre of a dark field of large printed letters and illuminated the display with an electric spark. The illumination did not last long enough for an eye movement to be made away from the fixation point while the display was visible, and Helmholtz was unable to perceive all of the letters or even all of those near the fixation point. However, by deciding in advance of the illumination which part of the display to attend to, he was able to recognise groups of letters in the attended region. Moreover, he was able to voluntarily shift his attention to different regions of the display while maintaining eye fixation on the central illuminated pinhole. This finding that observers can direct an internal visual

attentional mechanism to different areas of visual space independent of eye position has been replicated by a number of independent researchers more recently (Eriksen & Hoffman, 1972, 1973; Hoffman & Nelson, 1981; Posner, 1978, 1980).

In a typical covert orienting experiment, the subject's task is to make a simple response when a target is detected in the visual field (Posner, 1980). Prior to the onset of the target a warning cue is presented that is either neutral (uninformative with respect to the target location), valid (correctly predictive of the target location), or invalid (falsely predictive of target location). Eye movements are controlled in two ways. Either the stimulus onset asynchrony (SOA) from cue to target is shorter than the time needed to make an eye movement (150-200ms), or eye movements are monitored in situations where the cue to target delay exceeds this limit. The typical finding is that the response for detection is faster on valid trials than neutral trials and slower on invalid trials than neutral trials. Even though the status of neutral trials is not yet clear (Gawryszewski, Riggio, Rizzolatti & Umilta, 1987; Jonides & Mack, 1984), it is possible to demonstrate the benefits and costs of the covert orienting of attention by calculating the difference in reaction time between neutral and valid trials and between invalid and neutral trials respectively.

Data from patients with various brain lesions has led Posner and Cohen (1984) to propose the 'spotlight' model of visual attention and to distinguish three aspects of it:

1. the ability to engage attention to a target;
2. the ability to disengage it and
3. the ability to shift attention from one target to another

Posner and colleagues have also attempted to associate these attentional processes with specific brain areas. Rafal and Posner (1987) argue that patients with lesions to a forebrain structure, namely the thalamus have problems in "engaging" their attention on stimuli

contralateral to the lesion side, while the pattern of results obtained from a group of patients with lesions to the parietal region of the brain would suggest problems in "disengaging" attention from ipsilateral stimuli to detect stimuli on the contralateral side (Posner & Cohen, 1984). Patients with lesions to parts of the midbrain, including the superior colliculus have difficulty shifting their attention vertically (Posner et al., 1985).

One of the limitations of the spotlight model is the lack of a mechanism that varies the spatial extent of the beam. Based on evidence that attentional focus can range from a broad extent throughout the visual field to a fine focus at a particular point of interest, has led Eriksen and his colleagues (Eriksen & Yeh, 1985; Eriksen & St. James, 1986) to propose that attention be likened to a 'zoom lens'. That is, attentional resources become more concentrated as the spatial extent of attentional focus is decreased. Furthermore, when attention is shifted, it is claimed to be defocused at one location and then refocused at another location.

2.4.2 Relationship between covert and overt attentional systems

While it has been demonstrated through performance in laboratory attention tasks that we are able to shift visual attention independently of eye fixation, this seems unnatural and effortful. Observations that the locations of attentional focus and eye fixation correspond so frequently in the real world has led to speculation concerning the relationship between them. One view is that attention shifts always precede eye movements (saccades) to their destination and attention plays a role in the programming of these eye movements.

Saccades are rapid, ballistic changes in eye position that occur at a rate of about 3-4 per second (Becker, 1991). The eye is essentially blind during these movements and information is acquired during the relatively long fixations (approx 250ms) that intervene between saccades. Saccades are important during reading and scanning of scenes which require detailed analysis provided by the fovea. What is it that guides the eye from one

fixation to the next? One proposal is that attention serves as an advance scanner allocated to the periphery during the course of a fixation that communicates some form of location information to the saccade mechanism to program the location of the next fixation.

Experiments from the saccadic eye movement pattern during reading supports this assumption. For example, adult readers tend to fixate most of the 'content' words (nouns, verbs, adjectives, etc.) and skip short 'function' words (articles, conjunctions, etc.) in a text (Rayner & Pollatsek, 1989). Adult subjects appear to be 'previewing' words to the right before they are fixated. When these words are short or familiar, this preview is sufficient to identify the word, allowing it to be skipped. These results suggest that attention normally precedes the eye to its destination, however it is possible that this coupling of attention and saccades during reading is one of convenience and not necessity.

Shepard, Findlay and Hockey (1986) have provided some support for the notion that the link between attention and saccades is mandatory. They used a central arrow cue pointing to a box on the left or right of fixation to indicate the target of a saccade. Attention was manipulated by varying the probability of the target location. Thus, subjects could be instructed to move their eyes to the right while target probabilities favoured attending to the left. In these conflict situations, subjects detected targets more quickly when they occurred in the saccade target location than the position favoured by the probability manipulation. When saccades were not required, the probability manipulation had the expected effect of speeded responses to targets on the probable side. Shepard et al. (1986) concluded that making a saccade requires that attention be allocated to the saccade target location. It is not however necessary to adopt the opposite assumption that shifts of attention in the absence of saccades require involvement of the saccade system.

Further debate surrounds the mechanisms involved in mediating attention shifts and saccadic operations. One position is that attention and oculomotor operations are carried

out independently and share no functional components. For example, there may be a general spatial attention mechanism that is capable of indicating locations in visual space. Wurtz, Goldberg and Robinson (1980) provide support for this model with the finding that there are cells in the parietal cortex that increase their firing rate when an animal attends to a location independent of the task being carried out.

A second position is that both attentional and eye movement components share a common mechanism that encodes the location destination. This view is illustrated by the *oculomotor readiness* theory proposed by Klein (1980) and a related theory, the *premotor* theory of attention proposed by Rizzolatti, Riggio, Dascola and Umilta (1987). According to both theories, there is no response-independent representation of space being activated by an attentional mechanism. Instead, there are many different representations of space, each responsible for certain motor actions such as eye movements, reaching, locomotion, etc. Therefore attending involves activating motor actions in the area appropriate for the response system being used.

When experimental psychologists study attention, they take certain precautions in order to ensure that the observed empirical effects are attentional and not due to some other non-attentional factor. For example, in everyday life it is usual to look at what we attend to. However, the evidence reviewed above has revealed that the relationship between attention and eye movements is controversial. To avoid such controversy, the experimental chapters reported in this thesis using Posner type cueing paradigms involve covert attention shifting, whereby subjects are required to maintain fixation and to attend to stimulus events 'out of the corner of their eyes.' Moreover, it is possible that individuals with autism rely more on their covert attentional system, especially during social interactions. For example, the behaviour of individuals with autism can often resemble that of a shy, modest, socially inept typically developing teenager (though for very different

reasons), whereby both may show an avoidance of the need for direct eye contact during social interactions, perhaps relying more on their covert attentional systems.

2.4.3 Endogenous and exogenous orienting.

The second distinction that has arisen from the standard cueing paradigm reflects issues of control. Attentional cues can be divided into one of two types, endogenous and exogenous. Covert orienting can be elicited by a central symbolic cue such as an arrow, or by a peripheral cue, such as the brightening at the potential target site. Central symbolic cues such as arrows are said to be endogenous, i.e. under voluntary control. A valid arrow cue is one that points to the location of the subsequent target, whereas an invalid arrow cue is one that points in the other direction. If the proportion of valid cues is high relative to invalid cues, reaction times to detect the target are faster following a valid than an invalid cue.

In contrast, exogenous attentional cues are described as capturing attention at the cued location automatically. Performance enhancement occurs following a peripheral cue such as a brightening at the potential target site even when the cue does not predict where the target is most likely to appear. The effect of an uninformative but salient peripheral cue is reported to be reflexive or relatively automatic for a number of reasons. Firstly, the initial advantage on the cued side is unaffected by instructions to ignore the cue (Müller & Rabbitt, 1989) or even when the target is actually more likely to appear on the uncued side (Jonides, 1981; Spence & Driver, 1994). Secondly, exogenous orienting emerges quickly (Cheal & Lyon, 1991) and persists for a relatively short time (Müller & Rabbitt, 1989).

2.4.4 Inhibition of return

After the initial facilitatory effects of the exogenous spatial cue however, a performance deficit or inhibition can emerge. This phenomenon has been referred to as 'inhibition of return' (Posner & Cohen, 1984; Maylor & Hockey, 1985) or an inhibitory after-effect (Tassinari, Aglioti, Chelazzi, Marzi & Berlucchi, 1987). Within the first 50-150 ms

following an uninformative peripheral cue, responses to validly cued targets are faster than responses to invalidly cued targets. However this facilitation is short lived and generally inhibition becomes evident at the validly cued location by about 300ms, at which point invalidly cued targets are responded to faster than validly cued targets. The time course of this cueing effect has been explained by Posner and Cohen (1984) in the following way. The peripheral cue is assumed to attract attention to its location automatically, resulting in faster detection times for targets appearing at that location shortly after the cue. However this early facilitation is not observed at longer cue to target delays because the longer interval gives attention sufficient time to return to the central location and then moves on with an inhibitory bias against returning to regions of space that have been previously attended. Thus inhibition of return (IOR) can also be observed when a brief luminance increment occurs at the central fixation point after the peripheral cue and prior to the target event. This central brightening presumably summons attention away from the cued location, allowing IOR to occur. The utility of a bias that favours novelty may be important in preventing perseverative types of error in behaviour. Such a mechanism would be useful in visual search, for example, where having searched a location, it would be beneficial to avoid immediately searching there again (Klein, 2000).

Although inhibition of return does occur for exogenous cues in covert orienting studies, it is not seen following an endogenous attentional cue (arrow pointing left or right) (Posner, Rafal, Choate & Vaughan, 1985). A central or endogenous cue will only activate IOR if an overt eye movement occurs in response to a central endogenous cue, or when an eye movement is planned, not made and then 'cancelled' by the subject (Rafal, Calabresi, Brennan & Sciolto, 1989).

In summary, contemporary visual attention research has made the distinction between covert and overt orienting and the relationship between them is the subject of

much debate. Posner has proposed a 'spotlight' model of covert visual attention and has identified three possible brain areas involved in processing, namely the thalamus, the parietal region and the superior colliculus. In addition, there are several qualitative differences between exogenous and endogenous mechanisms for orienting attention (Jonides, 1981; Klein, Kingstone & Pontefract, 1992; Müller & Rabbitt, 1989; Posner & Cohen, 1984), which has given rise to the claim that different neural substrates underlie the two mechanisms. Subcortical structures such as the superior colliculus have been associated with exogenous orienting (Rafal, Henik & Smith, 1991), whereas many brain areas have been suggested to be involved in the voluntary allocation of attention, most notably the parietal and frontal cortices (Mesulam, 1981; Petersen, Robinson & Currie, 1989).

These two important distinctions derived from contemporary attention theory are important in interpreting the pattern of some of the data in the attention-cueing studies in individuals with autism that are reviewed in the next section.

2.5 EMPIRICAL STUDIES ON ATTENTION IN AUTISM

Anecdotal reports of the behaviour of individuals with autism could be consistent with abnormalities in either attention, inhibition or both. Kanner's (1943) original description of the disorder emphasised "the inability to experience wholes without full attention to the constituent parts" (p.38). Reports by clinicians, teachers and parents also suggest abnormal attentional focus (Hayes, 1987). In many instances autistic children appear oblivious to other people and often become fascinated with certain objects and may spend an excessive amount of time repeating the same activity, excluding the rest of the world (Lovaas, Koegel & Schreibman, 1979). This repetitive pattern of activity has long been assumed to function as a coping mechanism (Hutt et al., 1964; Hutt & Hutt, 1965, 1970; Zentall &

Zentall, 1983; Goodall & Corbett, 1982), however this assumption has recently been challenged and it has been suggested that an executive dysfunction may explain repetitive behaviour by a failure to inhibit ongoing action (Turner, 1997). However the empirical evidence for both attentional deficits and inhibitory problems in individuals with autism has produced mixed results.

Lovaas, Schreibman, Koegel and Rehm (1971) were among the first to investigate the attention of individuals with autism by experimental means. They reported that the attention of children with autism is overfocused so that they respond to fewer components of a complex stimulus than do normal or mentally handicapped controls. Lovaas and colleagues proposed that children with autism showed evidence of stimulus overselectivity, with the result that they often responded to minor and irrelevant cues in the environment, which in turn reduces their ability to generalise knowledge or skills learned in one environment to another. However this proposal has been criticised as the results failed to discriminate between children with autism and children with low IQ (Plaisted, 1999).

In spite of this, Rincover and Ducharme (1987) proposed that stimulus overselectivity was visible in autism when stimulus cues were spatially separated. These authors used the term 'tunnel vision' to refer to this overfocused attention. They compared the stimulus control acquired in children with autism to typically developing children matched on mental age, on two types of task; one where the target attributes (form or colour) were overlapping and the other where the target attributes were spatially separated. They found that the children with autism responded to both colour and form when these dimensions were overlapping, however when the form and the colour of the stimulus were separated in space, the children with autism responded to the form rather than the colour.

They argue that because this overselective responding only manifests itself when the attributes are spatially separate, this would suggest a narrowing of attentional gaze.

In a similar vein, Townsend and Courchesne (1994) have suggested that individuals with autism may have an overly selective 'spotlight' of attention. In a study involving eight adults with autism (5 with parietal abnormalities) and 10 normal controls, subjects were required to view a screen containing five boxes, one of which was red signalling the location to be attended. The subjects were instructed to press a button when the circles (target stimuli) appeared in the red box (attended location), and ignore the circles (non-target stimuli) that occurred in white boxes at the other four (unattended) locations. The fastest response times to correctly detected targets were from subjects with autism and parietal abnormalities. Using electrophysiological methods, these authors also found that subjects with autism with parietal abnormalities showed extremely narrowed regions of attention related sensory enhancement of visual stimulation and demonstrated the narrowest distribution of spatial attention as evidenced by the P1 attention response of the event-related potential. This raises the possibility that autism may be associated with parietal abnormalities which produce deficits in spatial attention, however no comparison group of individuals, with parietal lesions but without autism, was included in this study therefore this proposal remains to be established. However, it should be noted that Bryson, Wainwright-Sharp and Smith (1990) argue that autism can be likened to a developmental spatial neglect syndrome.

Further evidence suggesting a narrowing of attentional focus was proposed by Wainwright and Bryson (1996). These authors examined lateral differences in spatial attention in high functioning young adults with autism. They employed a target detection task in which participants were required to detect simple lateralised stimuli. The chronological age (CA) control group consisted of 10 normal males matched on age (mean

age 23 years 6 months) and handedness. A group of 10 younger normal males (mean age 11 years 9 months) were matched on handedness and on receptive language ability as measured by the Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn & Dunn, 1981). Like the normal adults, the individuals with autism showed a reliable left field advantage for detecting simple visual stimuli.

In a second experiment, central targets were included on the assumption that their presence might differentially influence the responses of individuals with autism. Different patterns of responses were exhibited by each of the three groups. The CA controls responded more quickly to lateral than to central targets, MA controls showed no differences in response times, while the high functioning adults with autism showed the opposite, but non-significant pattern of faster RTs to central than to lateral targets. The results of the CA controls is somewhat unexpected, due to the basic architecture of the eye and also previous research (Poffenberger, 1912) has shown that participants are faster to respond to central targets than to lateral targets.

In another follow up experiment the task demands were increased from detection to identification. In this condition the comparison groups responded with about equal rapidity to central and peripheral targets, whereas the individuals with autism responded more slowly to the peripheral targets. They argue that these results are consistent with previous reports of overfocused attention ("tunnel vision"; Rincover & Ducharme, 1987), and of difficulties disengaging and/or shifting attention in space (Wainwright-Sharp & Bryson, 1993). An alternative possibility could be that the individuals with autism have reduced visual acuity with distance from the fovea.

Burack (1994) has recently challenged the view that individuals with autism invariably suffer from a restricted focus of attention. He compared the speed of target discrimination under conditions that varied with regard to the absence of a spatial window

cue and the number and location of non-target distracters. Based on the tunnel-vision hypothesis (Rincover & Ducharme, 1987), individuals with autism should be less influenced by distracters and less able to benefit from the spatial window cue that could be used to facilitate focusing on the target. However the results did not support this hypothesis. The performance of the individuals with autism improved the most with the presence of the window when no distracters were present but this effect was negated when distracters were present. Burack (1994) suggests that this pattern of results is consistent not with a fixed narrow spotlight of attention but rather a deficit in appropriately sizing the attentional lens.

2.5.1. Endogenous orienting of attention

Other lines of research have also suggested that children and adults with autism have difficulty shifting attention at will. For example, Courchesne et al. (1994) reported that the performance of individuals with autism was slower than control subjects on tasks that require rapid attentional shifts between stimuli. In this experiment, subjects with autism, subjects with acquired cerebellar damage and IQ matched normal individuals were required to detect infrequent target stimuli and to alternate attention between visual and auditory channels as signalled by the appearance of a target stimulus. The results of this study indicated that compared to control subjects, both subjects with autism and subjects with acquired cerebellar damage were impaired in the ability to shift attention when 2.5s or less had elapsed since the last target detection. No group differences were reported when more time (>2.5-30s) had passed.

Recently, Wainwright-Sharp and Bryson (1993) have reported evidence to indicate that the attentional problems in autism are also manifest in rapid intra-dimensional shifts. These authors found that individuals with autism had difficulties shifting attention during Posner's endogenous covert visual orienting task. Wainwright-Sharp and Bryson (1993)

compared the performance of a group of relatively high-functioning adolescent/young adult males with autism (N=8) or Asperger's syndrome (N=3) to a group of typical males using a Posner type task with symbolic cues. The control group was matched for chronological age and handedness but not for IQ, which was a covariate. In this task design an arrow or horizontal line was presented at fixation. The arrow indicated the location of the subsequent target in either the left or right visual field whereas the horizontal line denoted the neutral condition and gave no information about the subsequent target location. In a block of trials, 60% of cues were valid, (correctly indicating the location of the subsequent target), 20% invalid, (incorrectly indicating the location of the target) and 20% were neutral (giving no information about subsequent target location). The cue remained on the screen for either 100 ms or 800 ms stimulus onset asynchrony. As expected, the results show that the normal group respond more quickly to valid than to invalidly cued targets at both SOAs. However with symbolic cues of brief duration (100 ms SOA) the individuals with autism failed to show the normal RT advantage for validly cued targets. These authors conclude that this result is consistent with a deficiency in some fundamental information-processing and attentional operation. Previous research with normal subjects has revealed that validly cued targets are detected faster than invalidly cued targets, even when cues are presented for as little as 50 ms (Posner, 1978) With brief SOAs the subjects with autism may be unable to rapidly shift their attention or alternatively it could reflect a more basic deficiency in interpreting briefly presented symbolic information. The subjects with autism also showed larger than normal validity effects, as evidenced by their particularly long RTs to invalidly cued targets in the 800 ms SOA condition. Evidently, these authors suggest that the simple act of engaging attention is intact in individuals with autism because their RTs were typical in the validly cued

trials, however, something about the operations of engage, shift and disengage may be impaired.

There may have been methodical shortcomings in the design of this study. Wainwright-Sharp and Bryson (1993) discuss the SOAs in terms of covert and overt orienting. They suggest that 100 ms SOA is a measure of covert orienting as this assumes too little time to make an eye movement and 800 ms SOA as a measure of overt orienting. However there is no mention of eye movements in this task or whether all subjects returned their attention to the fixation point before each trial. Both SOAs were equally and randomly distributed within conditions and subjects not returning to fixation may have confounded their results. They also did not include catch trials, so we are unsure if subjects are actually waiting for the target to appear before they respond. An analysis of the anticipatory responses may have provided useful information regarding this point. Although these were excluded from the analyses, exact figures were not reported for each group. A further issue to be considered is the role that level of cognitive functioning may play in determining the pattern of results on this visuospatial cueing task. In the Wainwright-Sharpe and Bryson (1993) study, the group with autism were of lower mean IQ than the comparison group, although this acted as a covariate in the analyses.

2.5.2 Exogenous orienting of visual attention

Using an exogenous covert shifting paradigm, Townsend, Courchesne and Egaas (1996) found that individuals with autism (with or without additional parietal abnormality) showed significantly longer RTs to targets at an expected or validly cued location when they had little time (100ms) to orient attention but RTs that were as fast as those of the normal control group at the longer cue to target delay of 800ms. Moreover those with additional parietal abnormality were also slow to detect information outside their attentional focus. However, methodological issues such as the matching of control subjects

on measures of IQ apply to this study also. Although the mean IQ of each of the two groups with autism was similar to that of the control group, large standard deviations around the mean in the group with autism suggests that the autistic groups may have contained some individuals with IQs well below the normal range. Plaisted (2000) has suggested therefore that the pattern of results displayed on visuospatial cueing tasks may relate to level of intellectual functioning rather than to any characteristic of autism.

However, this pattern of findings was replicated by Townsend et al. (1999). These authors acknowledge that the results showing slowed attention orienting could also reflect slowed response preparation. They then rule out this possibility by using a further target discrimination task, in which the orientation of the target was required with accuracy as the dependent measure. With only 100ms to orient attention, developmentally normal controls were as accurate as they were at longer cue to target intervals. Subjects with autism and subjects with acquired cerebellar lesions, on the other hand, showed maximal performance after the longest cue to target interval.

Adopting a similar exogenous cueing paradigm, Casey, Gordon, Mannheim and Rumsey (1993) found that autistic savants took longer to respond than controls and showed larger validity effects when attention was cued to the opposite location from the target. However these findings should be regarded as preliminary because of differences in the general level of functioning between the savants with autism and the comparison subjects and the savants being an unrepresentative sample.

One study has failed to demonstrate a selective impairment shifting attention on low-level tasks of attentional cueing in autism. Burack and Iarocci (1995) found no differences between a group of 12 low functioning individuals with autism and matched comparison groups using a covert attention shifting paradigm. Here the cue to target SOA was 150 ms, a time frame appropriate for measuring covert orienting, and the cue provided

no information about the location of the subsequent target. Yet all subjects displayed the fastest RT when the target appeared at the same location as the cue. While the children with autism were overall slower to respond, they showed patterns of responding similar to those in the other two groups, indicating no specific deficit in reflexively disengaging and/or shifting attention.

While the results of most of these studies are interpreted in terms of Posner's 'spotlight' model of attention, Plaisted (2000) has suggested that it might be the case that theories of the attentional spotlight and slowed attention shifting according to Posner's attentional framework are inappropriate ones to apply to this data. For example, Courchesne et al. (1994) have suggested that the cerebellar abnormalities of individuals with autism prevent rapid attention shifting, resulting in slowed orienting to validly cued targets at short SOAs. However, on this account validity effects at short SOAs should be reduced or absent in groups of individuals with cerebellar abnormalities, because at short SOAs there should be insufficient time for attention to be oriented from the fixation point to the invalidly cued location: thus eliminating the need to disengage from the invalidly cued location, enabling subjects to allocate attention directly to the target at the time of its appearance. While the data from Wainwright-Sharp and Bryson (1993) supports this prediction, data from the Townsend et al. (1996) does not. Both groups of individuals with autism, one with both cerebellar and parietal abnormalities, the other with only cerebellar abnormalities, from the Townsend et al.'s (1996) study showed significant validity effects at an SOA of 100ms. Plaisted further suggests that it is unlikely that the cerebellar abnormality in the group with autism and parietal damage was responsible for their enhanced validity effect seen at the 800ms SOA, because this effect was not observed in the group with autism with cerebellar but without additional parietal damage. In addition, the idea that individuals with autism with additional parietal damage have a narrow

spotlight of attention (Townsend & Courchesne, 1994), or 'tunnel vision' (Rincover & Ducharme, 1987) predicts enhanced validity effects, which were observed in individuals with autism and parietal damage at both 100 and 800 ms SOAs. However, this interpretation of enhanced processing due to a narrow spotlight also predicts faster responding to validly cued targets, yet both groups of individuals with autism, regardless of parietal abnormality, showed slower responses at 100 ms SOA. While this could be explained instead by slow attention shifting due to cerebellar abnormalities, an attention-shifting deficit also requires the absence of a validity effect at 100ms SOA. As mentioned above enhanced validity effects were found at the short SOA of 100ms.

Given these inconsistencies and in light of recent challenges to the spotlight metaphor of attention (Juola, Bouwhuis, Cooper & Warner, 1991), Plaisted (2000) has suggested that a new model of attentional orienting as proposed by LaBerge and colleagues (LaBerge, 1995; LaBerge, Carlson, Williams & Bunney, 1997) may be usefully applied to the data from visuo-spatial orienting studies in autism. Briefly, the two process model proposed by LaBerge includes firstly, an attentional preparatory phase triggered by the cue and secondly a selective attention process triggered by the onset of the target. The preparatory phase corresponds to increased activity in posterior parietal cortex (PPC) with a Gaussian-like curve of activation around the location of the cue, in which the peak of distribution represents a peak of activity at the centre of the cued area with gradually decreasing activation on either side. Selective attention then produces activity at the point along the Gaussian curve corresponding to the location of the target, which is assumed to be determined by inputs from the dorsolateral prefrontal cortex (DLPFC). Thus, on valid trials, selective attention will add to the activity set up by preparatory attention, resulting in faster reaction times. In contrast, on invalid trials selective attention needs to boost the level of activity because the target has appeared at one of the tails of the Gaussian

distribution. Therefore, this model suggests that the additional time required to raise activity at the peripheral point results in an increase in reaction time. In this way, different patterns of activity are proposed to account for the cueing effect observed in attentional cueing studies.

Based on predictions derived from this model Plaisted (2000) has suggested a number of ways that visuospatial orienting may be disrupted in individuals with autism. For instance, the rate at which preparatory attention sets up the Gaussian curve of activity in the PPC may be slower in individuals with autism, or the spread of activity may be different than in typically developing individuals. Alternatively, selective attention could be affected by deficient inputs from the DLPFC or by inefficient processing of those inputs by the PPC. Any of these possibilities would result in less activity at the point of target presentation.

However criticisms and interpretations such as these are problematic in that Plaisted (2000) is comparing data from exogenous and endogenous attention shifting paradigms which from the review earlier have important differences. Clearly, these issues would be resolved by conducting both reflexive and voluntary cueing paradigms on the same subjects.

2.5.3. Visual search

In marked contrast to some of the evidence suggesting attentional deficits, a recent study by Plaisted, O'Riordan and Baron-Cohen (1998a) has reported that on tasks of visual search, individuals with autism performed at a superior level to that of control subjects matched for age and verbal mental age. A group of eight high-functioning children with autism and a group of eight normal children participated in two search tasks. In one task, the target shared colour with one set of distractors but was unique in shape - the feature search task. In the other, the conjunctive search task, the target shared colour with one set

of distractors and shape with another set of distractors. A typical finding among normal individuals is that target detection times increases linearly with increases in the number of distractors in the conjunctive search condition but does not increase at larger display sizes in feature search tasks (Duncan & Humphries, 1989; Treisman & Gelade, 1980; Wolfe, Cave & Franzel, 1989).

The results showed that in the feature search task, the children with and without autism displayed search times independent of array size, however in the conjunctive search task the RTs of the children with autism were not affected by the size of the array, whereas the normal children displayed the typical pattern of linear increases in RT with number of distractors. Plaisted, O'Riordan and Baron-Cohen (1998a) interpret these findings as evidence that children with autism are relatively more proficient at processing unique features and that this may underlie their superior performance on tasks such as the embedded figures test and the block design test.

However, although the subjects were matched on verbal MA (as measured by the British Picture Vocabulary Scale (Dunn & Dunn, 1981)), the children with autism were older and scored higher on a measure of spatial ability (the block design test of the Wechsler Intelligence Scale for Children –Revised [WISC-R]). Given the possible effect of the group differences in spatial ability on task performance and the fact that these authors interpret the findings as a possible cause of their good performance on the block design test these results can only be interpreted with caution. Future research could give these search tasks to groups matched on a measure of non-spatial, general IQ.

In summary, the research using variations of Posner's cueing paradigms in individuals with autism have produced some equivocal results. While some studies have suggested that shifting attention at will (Wainwright-Sharp & Bryson, 1993; Courchesne et al., 1994) and reflexively (Townsend et al., 1996; Casey et al., 1993) is deficient, one

study, with low functioning individuals with autism, has failed to show reflexive orienting of attention impairments (Burack & Iarocci, 1995). In comparison, there is tentative evidence to suggest that individuals with autism may have a superior ability in shifting attention as displayed by their faster target detection on a visual search task (Plaisted et al., 1998a). However, most of these studies suffer from methodological problems. In addition, direct comparisons across studies are problematic due to slight but important differences in task design. Future research could address these problems by using larger group sizes, ensuring subjects maintain eye fixation, the inclusion of catch trials and better matching of control subjects. Moreover, using both exogenous and endogenous cueing paradigms in the same group of subjects may solve some of the problems of interpretation of data across studies.

2.6 AIMS OF THESIS

The first aim of this thesis is to investigate the hypothesis that individuals with autism have difficulties in shifting attention (Courchesne et al., 1994). Furthermore, a recent research trend has been the use of computerised experimental paradigms designed to examine specific aspects of executive function to more precisely determine the nature of the executive function impairments underlying autism. This research has identified inhibitory mechanisms as a relatively spared component of executive function tasks (Ozonoff et al., 1994; 1997). The experimental studies reported in this thesis are designed to further explore visual attention shifting and inhibition in autism. Chapter 3 examines the hypothesis that individuals with autism have impairments in covert visuo-spatial attention shifting and inhibition using variations of Posner's (1980) covert attention tasks. Three cueing tasks were employed to investigate exogenous and endogenous orienting of attention and 'inhibition of return'. Methodological issues mentioned earlier are addressed. The experiments reported in Chapter 4 continue on the theme of exploring low-level

attentional impairments by comparing the performance of individuals with autism and a matched comparison group on two visual search tasks.

The remainder of the thesis is devoted to the investigation of social attention in autism. While attention is important for successful performance on low-level tasks typically used in research on visual attention, social exchanges are likely to tax attentional systems to a greater degree. Chapter 5 reviews the evidence on social attention in typically developing individuals before a consideration of joint attention behaviours in individuals with autism. There is some suggestion from a review of this literature that individuals with autism have a specific deficit in attending to social stimuli. However, this lack of joint attention could be caused by a deficit in the ability to shift or modulate attention or by an inability to use gaze direction or other social signals as a guide. The experiments in Chapter 6 address related issues including the ecological validity and social relevance of laboratory type tasks by examining attention-shifting contingent upon social cues. While the eyes are of undisputed importance in the resolution of where another person is directing their attention, other cues such as head orientation, body alignment or even pointing gestures may also provide important information in this regard. Chapter 7 examines the issue of the relative importance of head or eye gaze in the ability to reflexively shift attention. While social exchanges require the ability to follow the shifting of another's attention, it is also important to detect when someone is engaging their attention with you. Therefore it is important to detect when someone is directing their eye gaze at you. Given the evidence that individuals with autism show deviant patterns of eye gaze use and have difficulty using information derived from the eyes, combined with the results from the previous chapter, Chapter 8 explores the performance of individuals with autism on two gaze direction perception tasks. The general discussion in Chapter 9 is

intended to place the main findings in the context of the issues arising in the introductory chapters.

CHAPTER 3

Inhibition and covert attention shifting

3.1 INTRODUCTION

Thus, the bulk of evidence derived from attentional cueing paradigms supports the suggestion that individuals with autism have impairments in both their automatic and voluntary allocation of visual spatial attention, however most of these studies suffer from some methodological problems as depicted in Chapter 2.

The experiments reported in section 2.5 would suggest that both motor and cognitive components of inhibition are spared in autism, suggesting that impairments in inhibition are not contributing to their deficits on executive function tasks such as the WCST. However not all aspects of inhibition have been investigated. Given the inconclusive and sometimes contradictory evidence from studies on attentional orienting, the present study extends previous work on attention and inhibition in autism by using three variations of the covert orienting of visual attention task (Posner et al., 1985). This task allows examination of both attentional shifting and an inhibitory mechanism referred to as 'inhibition of return' (IOR) that is thought to be a low level attentional mechanism which provides efficiency of attentional deployment (Klein, 2000).

In a typical covert orienting attention task, subjects are required to respond as quickly as possible on detection of a target event whose probable location has been previously cued. Properties of attentional orienting are then inferred on the basis of response time differences to targets appearing in cued (valid), uncued (invalid) or neutral cued locations. The typical finding is that the response for detection is faster on valid trials than on neutral trials and slower on invalid trials than neutral trials (Eriksen & Hoffman,

1972; Posner, Walker, Freidrich & Rafal, 1984). These two effects are often referred to as the 'benefits' and 'costs' respectively of directing attention to a particular location in space prior to the target event.

However, after the initial facilitatory effects of an exogenous spatial precue, a performance deficit or inhibition is found to emerge. This effect has been referred to as inhibition of return (IOR)(Posner & Cohen, 1984; Maylor & Hockey, 1985; Klein, 2000). Within the first 50 - 150 msec following a peripheral precue, facilitation is typically evident at the cued location. Responses to validly cued targets are faster than responses to invalidly cued targets. Generally, inhibition becomes evident at the validly cued location by about 300msec, at which point invalidly cued targets are responded to faster than validly cued targets. IOR is seen as an attentional mechanism that favours novelty which prevents against processing of stimuli that correspond to previously attended events. This inhibitory mechanism may be useful in visual search, for example, where having searched a location, it would be beneficial to avoid immediately searching there again. In this sense, it may play an important role in preventing perseverative types of error.

The design of this study was thus able to examine three attentional mechanisms. Experiment 1 was designed to investigate exogenous shifting of visuospatial attention and IOR using a peripheral cueing paradigm. Experiment 2 further explored relatively automatic shifts of visual spatial attention at short cue to target delays using two types of neutral cue, no cue and a double cue. Experiment 3 examined the performance of individuals with autism on an endogenous visual orienting task using a central arrow cue.

Often efficiency of attentional deployment has been examined by comparing the magnitude of the invalid-valid RT difference between each group (Casey et al., 1993; Wainwright-Sharp & Bryson, 1993), termed the 'validity effect'. However it is important to note that there is no simple prediction relating the size of the validity effect to the

efficiency of attentional allocation. Similar validity effects in each group could reflect one of three possible outcomes:

1.Similar benefits on valid trials and similar costs of mis-orienting on invalid trials.

2. Smaller benefits on valid trials and larger costs on invalid trials.

3. Larger benefits on valid trials and smaller costs on invalid trials.

In this study costs and benefits were calculated with reference to the neutral condition. In consideration of the warnings of Jonides and Mack (1984) that the properties of neutral cues are poorly understood, the question posed was only whether the costs and benefits were different in the group with autism compared to the normal subjects and whether these changed with SOA.

3.2 METHOD – Study 1

Experiment 1 – Inhibition of return

Participants

Two groups of participants took part in this study: a group of eighteen high functioning adults with Autism Spectrum Disorders (ASD) (10 males, 3 females with a diagnosis of Asperger's Syndrome, 2 males and 3 females with a diagnosis of high-functioning Autism) and a control group of eighteen developmentally normal adults (13 males and 5 females). All adults in the group with ASD were attending a special residential provision for autism and all were reported by clinical service as having received a diagnosis of ASD by experienced consultant psychiatrists using the guidelines of standard criteria, such as those specified in DSM-IV (American Psychiatric Association, 1994) and ICD-10 (World Health Organisations System for classifying medical disorders, 1990). In addition, the results of other standard instruments such as the A-DOS from two subjects and the ADI from eleven subjects were available to confirm the diagnosis. The comparison group of normal adults was recruited from a local college of further education. Ability was assessed using 6 subtests of the WAIS-R (Weschler, 1981). The selected three subtests from the Verbal Battery were Information, Vocabulary and Arithmetic. Picture Arrangement, Picture Completion and Block Design were selected from the Performance Battery. The predicted full-length IQ was derived by prorating these six subtests (Crawford, Allen & Jack, 1992). Participant's characteristics are shown in Table 3.1. Unpaired t-tests revealed that the chronological ages, VIQ, PIQ and IQ of the two groups were not significantly different ([t (31.27)=-1,p=0.325], [t (29.16)=-.58, p=0.565], [t (34)=-.11, p=0.917] and [t (29.64)=-.27, p=0.792]) respectively. All participants had normal or corrected to normal vision. Three participants from the comparison group and two individuals with autism were left-handed.

Table 3.1. Participant characteristics

Group	N		AGE(y:m)	VIQ	PIQ	overall IQ
Autism	18	Mean	20.0	89.89	92.72	91.00
		SD	2.38	15.64	22.25	18.38
		Range	16.9-23.11	72-118	72-138	72-132
Normal	18	Mean	20.8	92.44	93.39	92.39
		SD	1.76	10.15	14.92	12.27
		Range	16.6-23.9	76-125	75-127	75-126

Stimuli and Apparatus

The covert orienting of visual attention task was presented on a 15-inch computer monitor controlled by a Macintosh 6200 PowerBook computer with one millisecond timing for control of stimulus display, recording of reaction times and error data. The visual display for this task consisted of three 4cm square black boxes. The central box enclosed a central fixation point marked by a round black dot. This was flanked by two 4cm square black boxes on the left and right set at 6.5 degree of visual angle. The peripheral target was a small black square presented in one of the boxes on either side of fixation. The participant was seated in front of the computer screen, while the head was held in a fixed position by a chin rest, 57cm away from and eye level with the stimuli. The screen subtended a retinal

angle of 13 degrees. Participants responded by pressing the space bar of the computer keyboard with their dominant hand.

Design

The experiment had a mixed design, with one between subjects factor of Group (Normal/Autism) and within subject factors of Stimulus Onset Asynchrony (SOA)(50, 150, 600 and 1000 ms), Cue (Valid, Invalid and Double) and Visual field (left and right). SOA, the time interval between onset of the cue and onset of the target, was randomly varied as an interval of 50, 150, 600 or 1000 msec. Spatial cues were either valid (correctly indicating the box in which the target subsequently appeared), invalid (indicating the box contralateral to that in which the target subsequently appeared) or double (giving no spatial information about subsequent target location). Spatial cues for the appearance of a target consisted of a brightening of one of the two peripheral boxes. Double cues for target appearance consisted of a brightening of both peripheral boxes. The box was brightened by flashing an outline border (6 pixels wide). Trials were designated as being right visual field (RVF) or left visual field (LVF) depending on the location of the target, not the preceding cue. Figure 3.1 depicts the task in diagrammatic form.

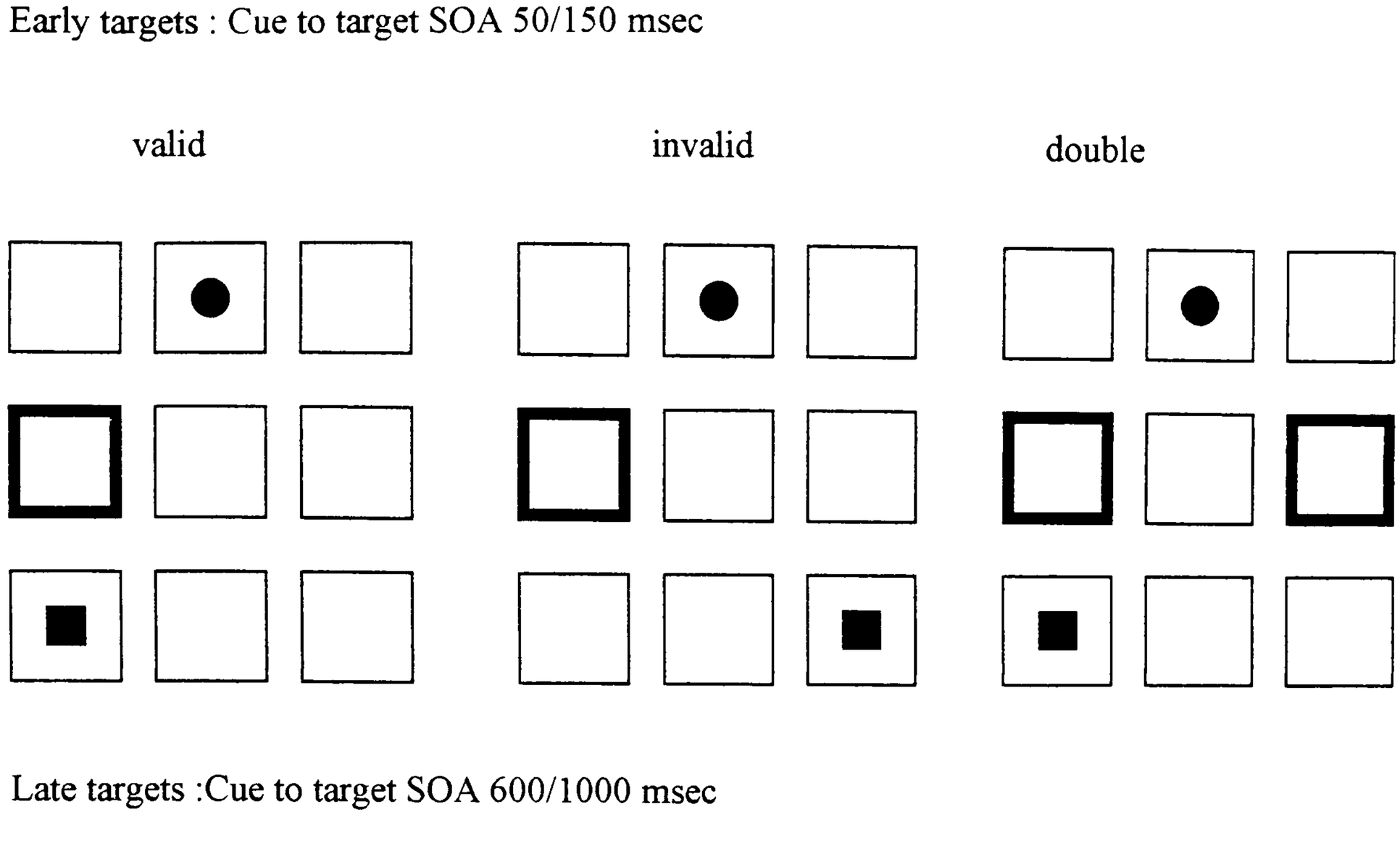

Figure 3.1. Diagram of the spatial task in Experiment

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At the start of each trial one of the peripheral boxes brightened. The brightening (cue) lasted for 150ms; 500 msec after the onset of the first peripheral cue, a second central cue was presented for 50msec. Targets (small bright black boxes inside the larger box) were presented either early (50 or 150 msec after the onset of the first cue) or late (600 or 1000msec after the onset of the first cue). Therefore when an early trial occurred, a second cue was never presented.

Top row - trials began with the basic visual display,followed by the cue onset (box brightening) and 50 or 150 msec later by the target.

Bottom row- trials began with the basic visual display, followed by the peripheral cue onset, followed by central redirecting cue and 600 or 1000 msec later by the target.

An experimental session consisted of 20 blocks of 24 trials, resulting in a total of 480 trials per session. These included 96 catch trials, in order to minimise anticipatory responses, where a cue appeared but no target followed. Rest breaks were offered after every 24 trials to meet individual requirements for optimal performance, however most participants completed three blocks (72 trials) consecutively before requiring a short break of approximately 1-2 minutes. Of the remaining trials 2/3 (256) had valid cues, 1/6 (64) had invalid cues and 1/6 (64) had double cues.

Target location was equally divided between left and right visual fields with SOAs being equally and randomly distributed across blocks. Targets remained on the screen until the participant depressed the space bar, or for a maximum of 1300ms.If a response was not made within this time, the trial was deemed a 'miss', excluded from the reaction time analyses and included in the error data analysis. Following a response a 500 ms inter-trial interval was imposed. As no response was required in catch trials, the display remained on the screen for 1300ms and was followed by a 500ms inter trial interval. Erroneous responses made on catch trials were categorised as 'false alarms'.

The fixation dot in the centre of the screen flashed to indicate the start of a new trial. For each subject, RTs less than 100msec were scored as anticipatory and included in error data analysis. Eye movements were monitored by the experimenter and trials where eye movements occurred were excluded. In addition to the participants reported in Table 1 four other participants were tested but their data was excluded from the final analysis. Three participants, two from the group with autism and one from the control group were unable to refrain from moving their eyes during 50% of trials and one participant from the group with autism was unable to make a response within the 1300ms timeframe on 50% of trials.

Procedure

Testing of individuals took place in an interview room either in the University of Durham or at the participant's institution. Ability testing was carried out on a separate occasion prior to the experiment. Each participant was introduced to the testing area and familiarised with the equipment. Participants were told that they were helping to find out how quickly people could detect a target without moving their eyes and were given a description of the task requirements.

Participants were told to keep their eyes on the round dot in the centre box of the screen. They were told that two boxes would be located on either side of this dot. Then following a short delay, either one of the boxes would briefly flash, or both boxes would flash. Subsequently a small target square would then appear in one of the two boxes. Participants were told that the delay between the box flashing and the appearance of the target may vary from trial to trial and also on some trials, the centre box may flash during this delay. They were told that on some trials no target would appear and that they were to refrain from responding on those trials. Participants were instructed to attend to the cues but to respond only to the target. The chin rest was introduced and explained that this was to ensure that their eyes were level with the display. Participants were encouraged to keep their eyes on the fixation point and told to try not to move either their head or their eyes. They were asked to press the space bar with their dominant hand as quickly as possible when the target square appeared. Participants were given 24 practice trials before the start of the experiment.

3.3 RESULTS

Reaction times

Preliminary analyses revealed no difference between left and right visual field responses for either the subjects with autism [$F(1,17)=0.008$, $p=0.931$], or the comparison group [$F(1,17)=1.095$, $p=0.310$]. Accordingly, responses were collapsed across this dimension for all following analyses. The median reaction time for each target delay and condition were calculated for each participant (median reaction time was used as a measure of central tendency in line with other research in this area (Posner & Cohen, 1984)). Figure 3.2 shows the mean of the median RTs for both groups. While the overall reaction times in the groups differ, the results with respect to cueing are similar: an early facilitation of the validly cued side (versus the invalidly cued side) which is eliminated at the longer SOAs of 600 msec and 1000msec (inhibition of return).

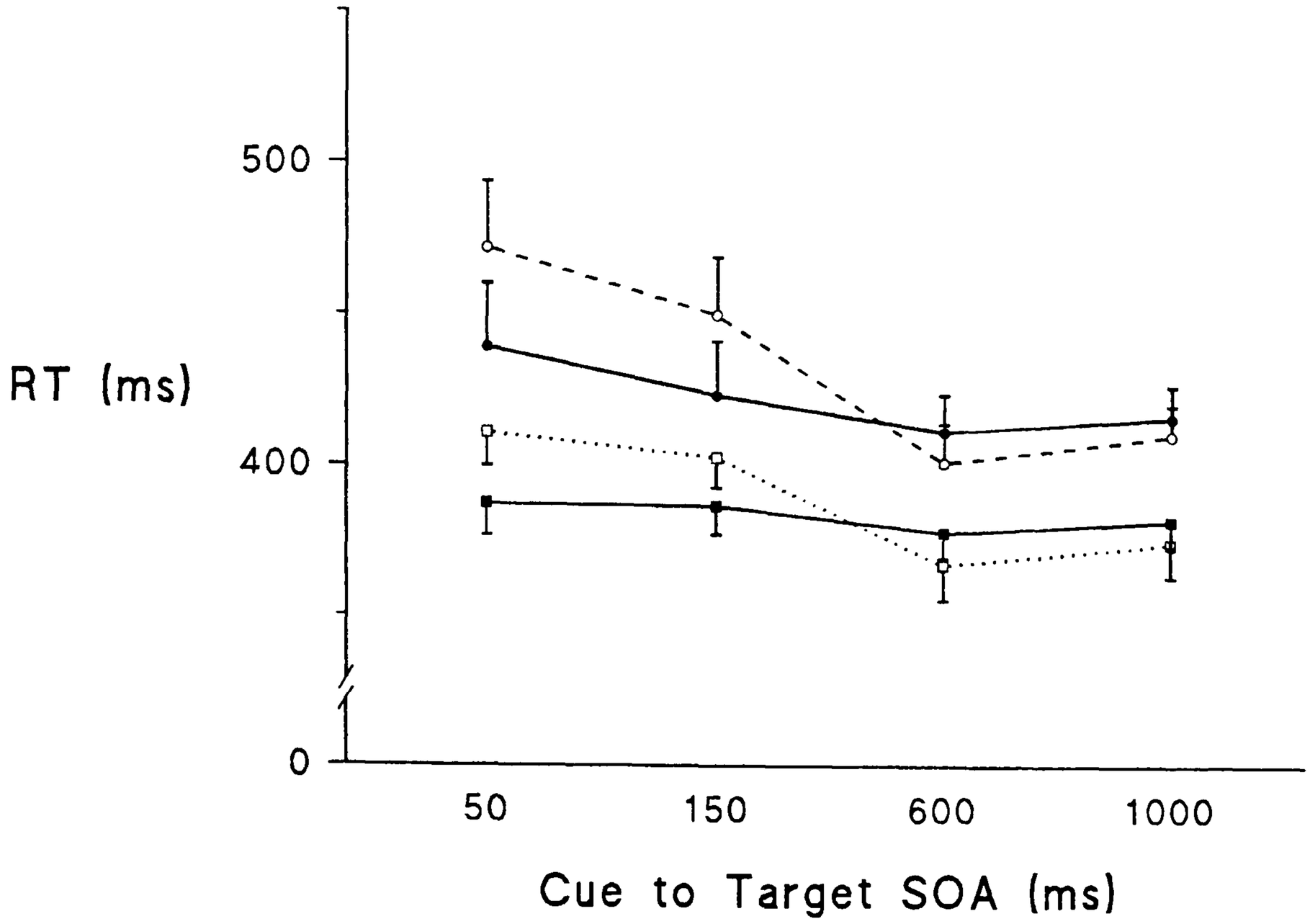


Figure 3.2. Mean (SEM) reaction times to targets occurring at varying intervals following the cue for both autistic and normal groups in Experiment 1. ○ Autism group invalid cue; ● Autism group valid cue; □ Normal group invalid cue; ■ Normal group valid cue.

The mean RT scores were compared using ANOVA with a between subject factor of Group (Autism/Normal) and within subjects factors of Cue (Valid/Invalid) and SOA (50,150,600 and 1000ms). This revealed a significant effect of Group, [$F(1,34) = 5.67$, $p<0.023$], a significant main effect of Cue [$F(1,34) = 6.62$, $p<0.015$], a significant main effect of SOA [$F(1.67,102) = 23.56$, $p< 0.001$] (Greenhouse-Geisser Epsilon corrected) and a Cue by SOA interaction [$(F2.41, 102) = 21.22$, $p<0.001$](Greenhouse-Geisser Epsilon corrected). Simple effects tests revealed that the Cue by SOA interaction was attributable to a significant effect of SOA for invalid trials [$F(3,102) = 28.8$, $p<0.025$] but not for valid trials [$F(3,102) = 2.35$, $p>0.05$] and significant effects of Cue for SOAs of 50ms [F (1,34)

= 20.13, p<0.025], 150ms [F(1,34) = 11.70, p<0.01], but not at SOAs of 600ms [F(1,34) = 2.84, p> 0.05] or 1000ms [F(1,34) = 1.16, p>0.05].

This pattern of data supports the results reported by Posner and Cohen (1984) where the faster responses occurring at the validly cued side at short SOAs reverses to an advantage towards the invalidly cued side at longer SOAs. While the simple effect tests do not show an advantage, merely comparable response times, it should be noted that there was a significant effect of SOA for invalid trials but not valid trials. This is also shown in Figure 3.2 where the validly cued side is relatively flat, while the invalidly cued side shows a reduction in RT with time. In most experiments a cue produces a reduction in RT with SOA, thus the relatively flat function for the cued side indicates that something is preventing the usual decrease of RT with SOA. This pattern of results is sufficient to determine an inhibition of return effect (Posner & Cohen, 1984).

To examine the 'validity' effect the mean of the RT scores of the invalid trials were subtracted from the valid trials at each SOA. The scores from both groups are shown in Table 3.2. These were compared using ANOVA with a between subject factor of Group (Normal/Autism) and a within subject factor of SOA (50, 150, 600 and 1000ms). This analysis revealed a main effect of SOA [F (3,102)=21.22, p<0.001] but no main effect of Group [F(1,34) <1, ns] and no Group by SOA interaction F(3,102)<1, ns].

Table 3.2. Validity effects in Experiment 1. A comparison of the mean RT at each SOA for valid and invalid trials of each group. Validity effect = valid-invalid trials.

	Autism				Normal		
SOA	Valid	Invalid	Validity Effect	SOA	Valid	Invalid	Validity Effect
50	439.5	472.19	-32.69	50	387.61	411.14	-23.53
150	424.28	450.92	-26.64	150	387.28	403.5	-16.22
600	412.72	402.36	+10.36	600	378.72	367.97	+10.75
1000	417.56	411.67	+5.89	1000	382.81	375.19	+7.62

Cost-Benefit Analysis

Although there were no significant differences between the groups in terms of validity effects a cost/benefit analysis was undertaken to examine this further. To examine the effect of the 'costs' associated with orienting to an invalid cue the mean RT scores of the invalid trials were subtracted from the double trials at SOAs of 50 and 150 ms. Figure 3.3 shows a comparison of the 'costs' and 'benefits' of both groups at 50, 150, 600 and 1000 ms. These were compared using ANOVA with a between subject factor of Group (Normal/ Autism) and a within subject factor SOA (50 and 150 ms). This revealed that the group with autism showed a relative greater cost associated with orienting attention to an invalid cue [$F(1,34) = 8.67$, $p<0.006$]. There was no significant main effect of SOA [$F(1,34)<1$, ns] and no Group by SOA interaction [$F(1,34)<1$, ns].

To examine the effects of the 'benefits' associated with orienting to a valid cue the mean of the median RT scores of double trials were subtracted from the mean of the valid trials at SOAs of 50 and 150 msec. This revealed that the normal group showed a

significantly greater benefit associated with a valid cue [F (1,34) = 5.41. P<0.026]. There was no significant main effect of SOA [F(1,34)=2.29, p=0.14] or a Group by SOA interaction [F(1,34) < 1,ns].

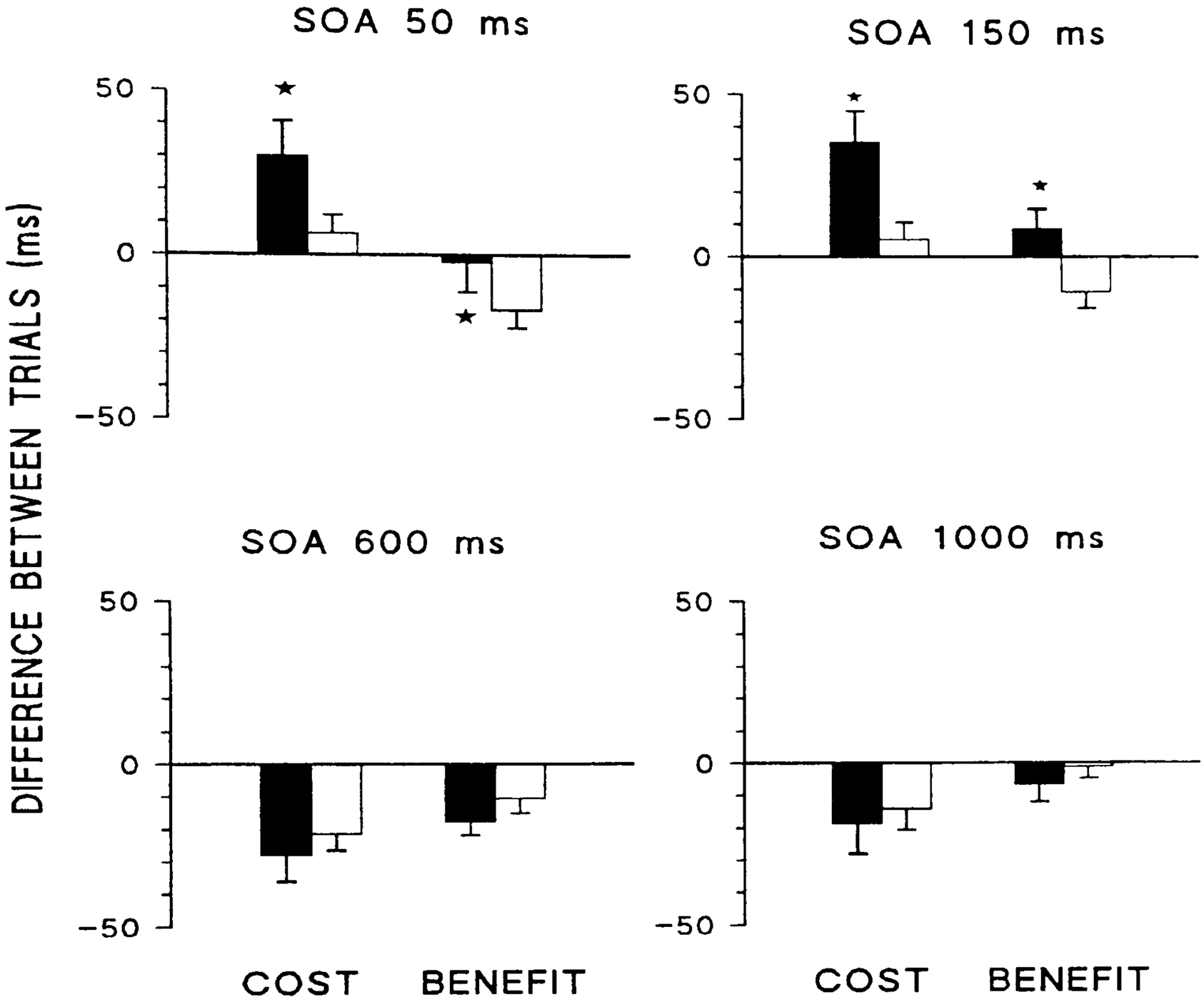


Figure 3.3.A comparison of the 'costs' and benefits' for both groups at each SOA in Experiment 1.

■ Autism group; □ Normal group. ★ P<0.05

This shows that at short cue to target delays of 50 and 150 ms there are different patterns of costs and benefits between the two groups, with autistic subjects showing larger costs

and less benefits of the attention directing cue. There were no group differences at the longer cue to target delays of 600 and 1000ms.

Error Data

Anticipations

A small number of 'anticipatory ' responses i.e. RTs less than 100 ms were excluded. These accounted for less than 0.1% of responses for each group. Given this very low rate of errors, no analysis was undertaken on this measure.

False Alarms

The mean percentage of error scores for catch trials was calculated for each group. The normal adults were able to withhold a response correctly on 98.96% of the catch trials. The autistic adults were able to withhold a response correctly on 98.09% of the catch trials. Independent sample t-tests revealed that the percentages of 'false alarms' in each group were not significantly different [t (34)=1.56, p=0.12].

Misses

Of the remaining 384 trials the normal adults failed to make a response within 1300msec on 0.39% of trials versus 1.28% for the adults with autism. Independent sample t-tests revealed a significant difference between the two groups on this measure [t (34)=2.37, p<0.03].

3.4 DISCUSSION

The results of Experiment 1 show that overall the reaction times of the group with autism were significantly slower than those of the matched comparison group. However, both the group with autism and the comparison group show a similar pattern of attentional cueing. When the onset of the cue was followed shortly after (50 or 150ms) by the onset of the target, detection times were faster at the validly cued than at the invalidly cued location. However, when the interval between the cue onset and target onset was 600 or 1000ms, detection times were slower at the validly cued than the invalidly cued location. This replicates data reported by Posner and Cohen (1984) for normal adults, revealing reliably slower detection times at valid as opposed to invalid locations when the interval between cue onset and target onset was 300ms or greater. In other words both groups show evidence of an intact low-level attentional mechanism – inhibition of return, which is a phenomenon that appears to reflect a form of bias favouring novelty (see Klein & Taylor, 1994; Rafal & Henik, 1994 for a review). Given these results it would seem that the inhibitory capacity of the group with autism was comparable to that of the matched normal controls, as shown in Figure 3.2 where the cross-over between valid and invalid trials is occurring after a comparable time delay in both groups.

These results are consistent with the results reported by Ozonoff et al. (1994) and Ozonoff and Strayer (1997) in their component process approach to extract the deficient cognitive processes involved in executive function tasks found in autism. They found no group differences on both motor and cognitive components of inhibition. Similarly Burack and Iarocci (1995) found no differences between relatively low functioning individuals with autism and matched controls in the ability to filter distracters in an attentional task. However, they are not concordant with accounts of 'overfocused ' attention in autism

(Lovaas, Koegel, & Schreibman, 1979; Rincover & Ducharme, 1987), a finding that could be interpreted as showing a superior inhibitory capacity among individuals with autism.

This paradigm also allowed the effect of exogenous covert attentional orienting to be examined. There were no significant differences between the two groups in terms of the 'validity effect'. However a cost-benefit analysis was conducted to ascertain the ambiguity inherent in validity effects. This analysis, although not definitive (Jonides & Mack, 1984) highlighted a difference between the groups. Specifically the group with autism displayed significantly greater cost associated with an invalid cue and less benefit from a valid cue than the comparison group. These differences were small and were only apparent at short cue to target delays (50 and 150ms).

The cost of orienting attention on invalid trials can be understood both within the spotlight metaphor of spatial attention made popular by Posner (1980) and within the zoom lens metaphor of attention favoured by Eriksen (Eriksen & Yeh, 1985). According to the spotlight metaphor, there are three distinct components of spatial attention that correspond to three stages involved in the operation of the spotlight: engagement of attention by a stimulus, disengagement from a stimulus and movement of attention to a stimulus (Posner et al., 1987). Larger orienting costs for the subjects with autism in this study suggest that they were slower to disengage from an invalid cue in order to attend to the uncued target. Less benefits associated with a valid cue would suggest that the individuals with autism are slower to shift their attention at short cue to target delays.

According to the zoom lens metaphor, spatial attention can be contracted or expanded. All stimuli within the attentional lens are processed in parallel, but the efficiency of processing varies inversely with the size of the field. Larger orienting costs for the autistic subjects in this study suggest that they were less able to flexibly expand the field of view on invalid trials and thus had to process the target with fewer resources.

These results are compatible with those of Courchesne et al. (1994) and Townsend et al. (1996, 1999) who found deficits in shifting attention during short time frames. Moreover, these results are convergent with results reported by Burack (1994) who has suggested that individuals with autism have difficulty in appropriately sizing the attentional lens.

However, the properties of neutral cues are poorly understood (Jonides & Mack, 1984), therefore it is possible that the reason that the individuals with autism failed to show comparable costs and benefits to the control group was because they found the neutral cue (double flash) too alerting. This prompted the design of experiment 2 which employed the same design at short cue to target delays of 50 and 150 ms using two types of neutral cue, both no cue and a double cue. As no significant differences were found between the two groups at the longer SOAs of 600ms and 1000ms these were omitted from Experiment 2. This also reduced the total number of trials required.

3.5 METHOD

Experiment 2 – exogenous orienting of covert visual spatial attention.

Participants

Two groups of participants took part in this study: a group of sixteen high functioning adults with ASD (9 males, 3 females with Asperger's Syndrome and 2 males, 2 females with high-functioning Autism) and a control group of sixteen (11 males and 5 females) developmentally normal adults. Fourteen of the group with ASD and eight of the control group participated in Experiment 1 approximately four months before. Recruitment and ability testing were as described in Experiment 1. Participants' characteristics are shown in Table 3.3. Independent sample t-tests revealed that the chronological ages, VIQ, PIQ and IQ of the two groups were not significantly different ([$t(28) = -0.06$, $p=0.95$], [$t(21) = 0.64$, $p=0.53$], [$t(31)=1.03$, $p=0.31$] and [$t(27) =0.79$, $p=0.44$]) respectively. All participants had

normal or corrected to normal vision. Three of the comparison group and two subjects from the group with autism were left-handed.

Table 3.3. Participant characteristics in Experiment 2

Group	N		AGE(y:m)	VIQ	PIQ	overall IQ
Autism	16	Mean	20.6	88.6	85.5	86.8
		SD	2.31	14.4	14.5	13.7
		Range	16.3-24.2	72-120	72-112	72-113
Normal	16	Mean	20.6	91.13	90.09	90.12
		SD	1.85	6.72	15.00	9.72
		Range	17.0-25.0	76-101	75-128	75-123

Stimuli and Apparatus

The stimuli were presented on a 15-inch computer monitor controlled by a Texas Instruments Travelmate 6030 computer with one millisecond timing for control of stimulus display, recording of reaction time and error data. The visual display for this task was identical to that in Experiment 1. Participants responded by pressing a button on a button box.

Design

The experiment had a mixed design, with one between subject factor of Group (Normal/Autism) and within subject factors of Stimulus Onset Asynchrony (SOA) (50 and

150ms), Cue (Valid, Invalid, No Cue and Double Cue) and Visual Field (left and right). All other aspects of the design were as for Experiment 1.

An experimental session consisted of 4 blocks of 68 trials, resulting in a total of 272 trials per session. These included 48 catch trials in order to minimise anticipatory responses, where a cue appeared but no target followed. Of the remaining trials 128 had valid cues, 32 had invalid cues, 32 had no cue and 32 had a double cue. Rest breaks of approximately 1-2 minutes were offered after every block. Target location was equally divided between right and left visual fields. SOAs were equally and randomly distributed across blocks. Targets remained on the screen until the participant depressed the button, or for a maximum of 1300ms. Error data was recorded as in Experiment 1.

Procedure

The procedure was similar to that in Experiment 1 except notice that the centre box may flash was omitted from the instructions. Participants were asked to press the button on the button box as quickly as possible when the target square appeared. Participants received 24 practice trials before the start of the experiment.

3.6 RESULTS

Reaction Times

As in Experiment 1, there was no effect of visual field for the group with autism [$F(1,15)=0.275$, $p<0.61$] or the comparison group[$F(1,15)= 0.07$, $p<0.79$] and this dimension was collapsed for all following analyses. The median reaction time for each target delay and condition were calculated for each subject. Figure 3.4 shows the mean RTs for both the group with autism and the comparison group.

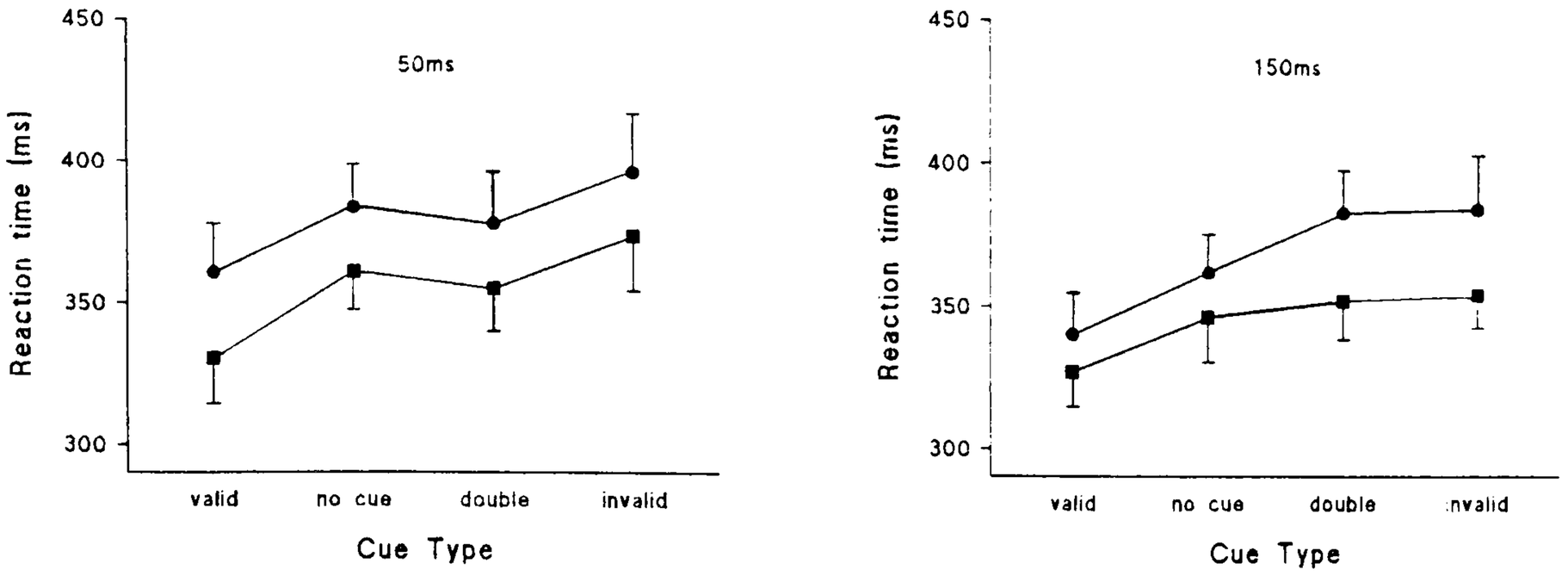


Figure 3.4. A comparison of reaction times in response to each attentional cue in Experiment 2. The left graph displays the mean reaction times (RT) ±SEM from both the comparison group and the group with autism at a cue to target SOA of 50ms. The right graph displays the results from the comparison group and the group with autism at a cue to target SOA of 150ms. Subjects:● Autism, ■ Normal.

The mean RT scores were compared using ANOVA with a between subject factor of Group (Autism/Normal) and within subject factors of Cue (Valid/Invalid/No Cue/Double) and SOA (50 and 150ms). This revealed significant effects of Cue [$F(3,90)=21.49$, $p<0.001$] and SOA [$F(1,30)=9.08, p<0.005$]. This shows that both groups were faster on valid than invalid trials with no cue and double trials lying somewhere in between. Both groups of subjects were also faster with a longer cue to target delay. There were no significant differences in RTs between the two groups [$F(1,30)= 1.33$, $p=0.26$] and all other interactions were not significant (Cue by Group [$F(3,90)= 0.29$, $p=0.84$], SOA by Group [$F(1,30)= 0.09$, $p=0.76$], Cue by SOA [$F(3,90)= 1.92$, $p=0.13$] and Cue by SOA by Group [$F(3,90)= 0.94$, $p=0.42$].

To answer the question of whether there were differences between the effects of orienting to a neutral (no cue) compared to a double cue a three way repeated measures ANOVA was conducted with one between subject factor of Group and within subjects factors of Cue (No and Double) and SOA (50, 150ms). This analysis revealed no significant differences between the two groups [$F(1,30)= 1.34$, $p=0.25$]. There was a main effect of SOA [$F(1,30)=4.23$, $p<0.05$] indicating that both groups were faster at longer cue to target delays and a Cue by SOA interaction [$F(1,30)= 8.26$, $p<0.007$]. Simple effect tests revealed that this interaction was attributable to a significant effect of SOA for the No Cue trials [$Fs(1,30)= 10.10$, $p<0.01$] but not for double trials [$Fs(1,30)=0.07$, $p>0.05$]. The effects of Cue at SOAs of 50ms [$Fs(1,30)<1$, ns] and 150ms [$Fs(1,30)=3.66$, $p>0.05$] were not significant.

To examine the 'validity' effect the mean of the RT scores of the invalid trials were subtracted from the valid trials at each SOA. The scores from both groups are shown in Table 3.4. These were compared using ANOVA with a between subject factor of Group (Normal/Autism) and a within subject factor of SOA (50, 150ms). No significant results were found. (Group [$F(1,30)= 0.36$, $p=0.56$], Group by SOA [$F(1,30)= 1.43$, $p=0.24$] and SOA [$F(1,30)= 0.09$, $p=0.76$].

Table 3.4. Validity effects in Experiment 2. A comparison of the mean RT at each SOA for valid and invalid trials of each group. Validity effect = valid-invalid trials.

SOA	**50**			**150**		
	Valid	Invalid	Validity	Valid	Invalid	Validity
Autism	360.84	396.20	-35.36	340.36	384.89	-44.53
Control	330.47	373.25	-42.78	327.09	354.44	-27.35

Cost-Benefit Analysis

To examine the effect of the 'costs' associated with orienting to an invalid cue the mean RT scores of the double trials were subtracted from the invalid trials at SOAs of 50 and 150 ms. These were compared using ANOVA with a between subject factor of Group and a within subject factor SOA (50 and 150 ms). This analysis revealed no significant differences between the two groups [$F(1,30)<1$,ns] and no main effect of SOA [$F(1,30)= 2.59$, $p<0.12$] or SOA by Group interaction [$F(1,30)= 0.001$, $p<0.98$].

To examine the effects of the 'benefits' associated with orienting to a valid cue the mean RT scores of double trials were subtracted from the mean of the valid trials at SOAs of 50 and 150 ms. These were compared using ANOVA with a between subject factor of Group (Normal/Autism) and a within subject factor of SOA (50 and 150 ms). This analysis revealed no significant differences between the two groups [$F(1,30)<1$,ns], no main effect of SOA [$F(1,30)= 2.94$, $p=0.09$] and no SOA by Group interaction [$F(1,30)=2.58$, $p=0.12$].

Because there were no differences between the no cue trials and the double cue trials in both groups, only the costs and benefits of the double trials are reported above however both comparisons are depicted graphically in Figure 3.5.

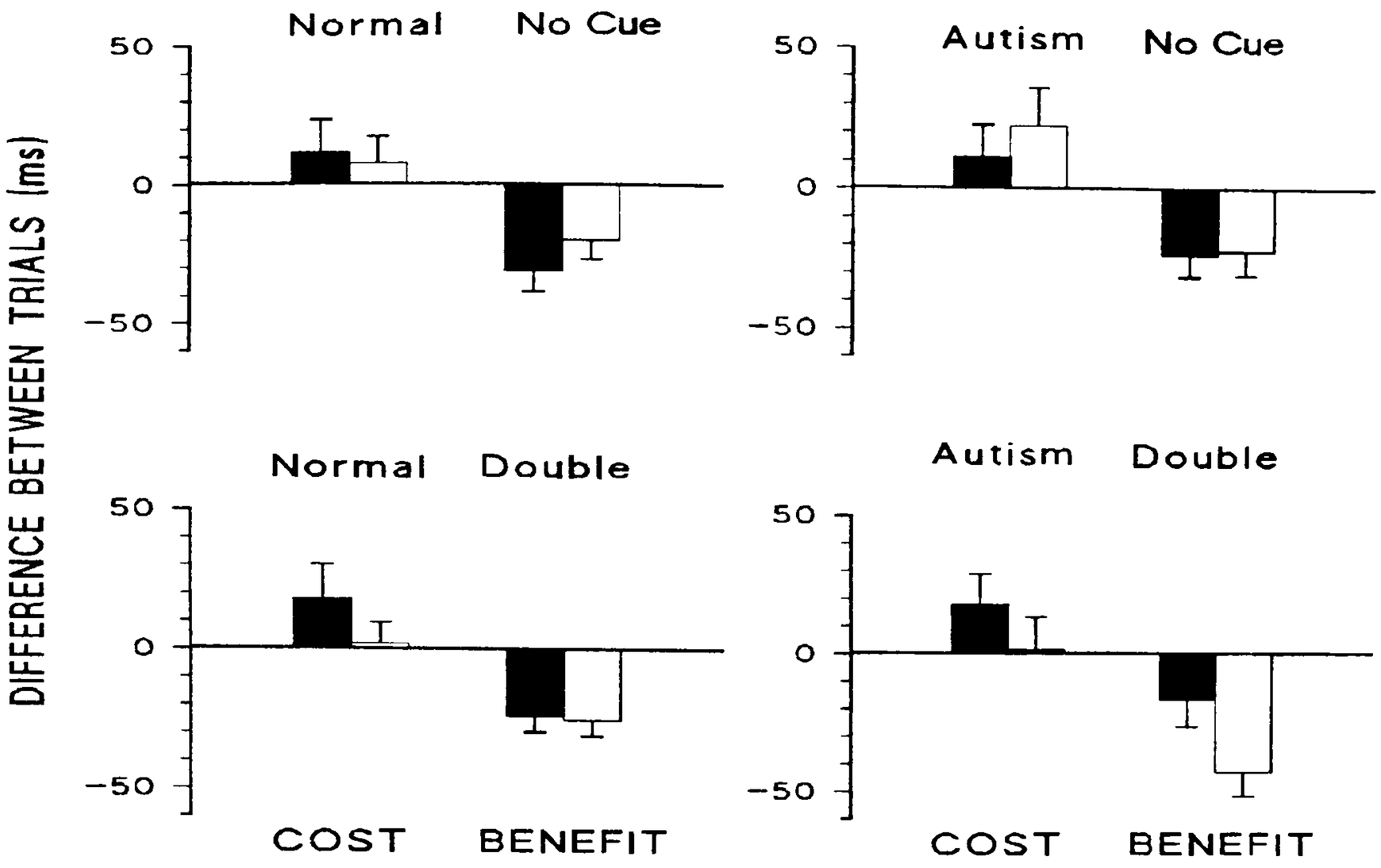


Figure 3.5.Mean (+SEM) of the difference between the costs and benefits following a neutral (No) cue and a neutral (double) cue for both the autism group and the comparison group in Experiment 2. ■ Cue to target SOA of 50ms; □ Cue to target SOA of 150ms.

Error Data

Anticipations

A small number of 'anticipatory' responses i.e. RTs less than 100ms were excluded. These accounted for less than 1% of responses for each group. There were no significant differences between the two groups [t(30)=-0.63, p=0.53].

False alarms

The mean percentage of catch trials on which subjects incorrectly responded were calculated for each group. The control group produced a 'false alarm' response on 6% of

trials in comparison with 10% for the group with autism. An independent sample t-test revealed no significant difference between the groups on this measure [t(30)= -1.58, p=0.12].

Misses

Of the remaining 224 trials the normal adults failed to make a response on only 0.3% of trials. The group with autism made 0.4% errors. Again this difference was not significant [t(30)=-0.48, p=0.63].

3.7 DISCUSSION

The results of Experiment 2 show no significant differences between the group with autism and the comparison group in their relatively automatic allocation of visual attention at short cue to target delays. Also, analyses designed to compare the effects of a double cue with no cue produced no significant differences between the two groups. These results are in contrast to the small differences found in both overall reaction times and the costs and benefits at short SOAs between the two groups in Experiment 1. There are at least three possible reasons for this discrepancy. Firstly the task demands of the two experiments were different. Secondly, the participants were slightly different in the two experiments, with fourteen from the original group with autism and eight from the original comparison group available for re-testing. Finally, there may have been practice effects.

It may be possible to reconcile the failure to replicate the results of Experiment 1 in light of theories that disordered attention/arousal might underlie the symptoms found in autism. Dawson and Lewy (1989) suggest that children with autism suffer from a deficit in their arousal regulation and deficient orienting responses to novel stimuli. Experiment 2 required participants to be highly alert at all times with target stimuli appearing at a fast

pace. Clearly both groups found this task more difficult as evidenced by their increase in error data, however again there were no significant differences between the groups. When the task demands required participants to be alert at all times and respond to rapid stimuli as in Experiment 2, no differences were found between the two groups. In contrast, Experiment 1 varied from short cue to target delays to longer cue to target delays that did result in small group differences. The notion of a deficit in orienting to *novel* stimuli was not tested in this paradigm in view of the repetitive nature of the task. However, it seems that in this group of subjects with autism there was no pervasive deficits in reflexively shifting their attention.

These results are not convergent with other studies reporting attentional shifting impairments in individuals with autism using a similar exogenous covert shifting paradigm (Townsend et al., 1996; Casey et al., 1993; Townsend et al., 1999). However, as mentioned previously most of these studies suffer from some methodological problems. In these studies there is often no mention of including catch trials so there is no way of knowing whether participants are actually waiting for the target to appear before responding. Also, although the authors suggest that participants maintain fixation there is no mention of excluding trials where eye movements occur, an oversight that could confound the reaction time data

These results are however, consistent with the findings of Burack and Iarocci (1995) who also found no significant differences between low functioning individuals with autism and comparison groups in a similar shifting covert attention paradigm. In this study, following an exogenous cue, a target appeared to the left or right of fixation at an SOA of 150ms, a time frame appropriate for the measurement of covert orienting. Although they found that the children with autism were overall slower to respond to both validly and invalidly cued targets, the group with autism, a MA-matched group of developmentally

delayed individuals without autism and typically developing children all displayed fastest RTs when the target appeared in the same location as the cue, indicating no specific deficit in reflexively disengaging and/or shifting attention among the individuals with autism.

In view of the fact that this group of individuals with autism showed no impairments in their relatively automatic allocation of visual attention, Experiment 3 was designed to examine their performance on a task of voluntary attention shifting.

3.8 METHOD

Experiment 3- Endogenous orienting of covert attention

Participants

All participants who took part in experiment 2 were available for re-testing approximately 2 weeks later.

Stimuli and Apparatus

These were the same as Experiment 2

Design

The experiment had a similar design to Experiment 1 with one exception. The spatial cues for the appearance of a target in this experiment were either an arrow (valid/invalid) or a dash (neutral). All other aspects of the design were as Experiment 1. An example of the task is shown in Figure 3.6.

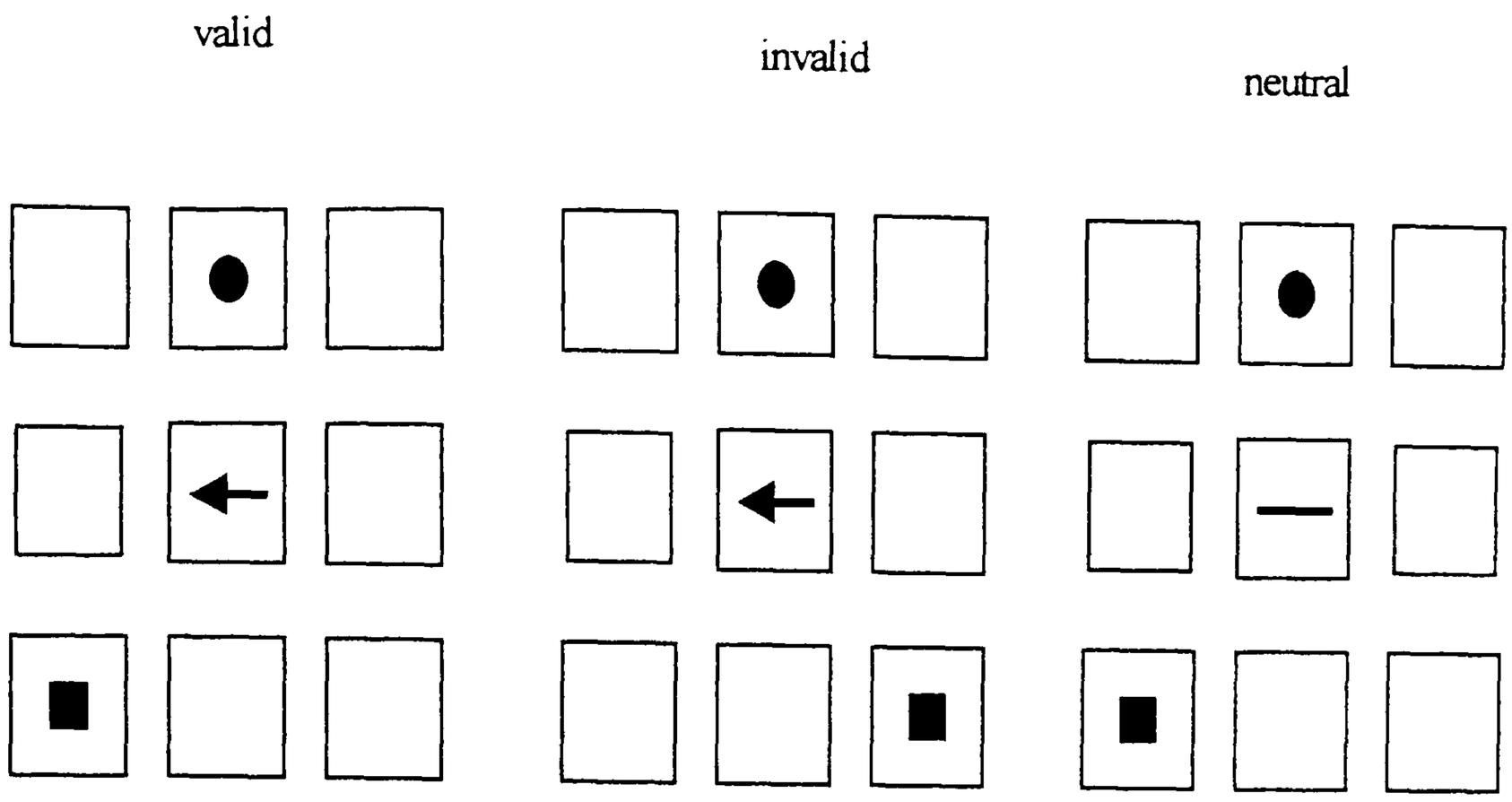


Figure 3.6. A diagram of the spatial cueing task in Experiment 3

Procedure

The procedure was identical to that described for Experiment 2 except that the participants were told that on 80% of the trials the arrow would point to the location of the target and 20% of the trials the arrow would point to the opposite box. A dash would suggest that the target could appear in either of the peripheral boxes. Participants completed 24 practice trials before the start of the experiment.

3.9 RESULTS

Reaction Times

The median RT for each target delay and condition were calculated for each subject. Figure 3.7 shows the mean RTs for both the group with autism and the comparison group. The left graph shows the RT for targets appearing in the left visual field. The right graph shows the RTs for targets appearing in the right visual field.

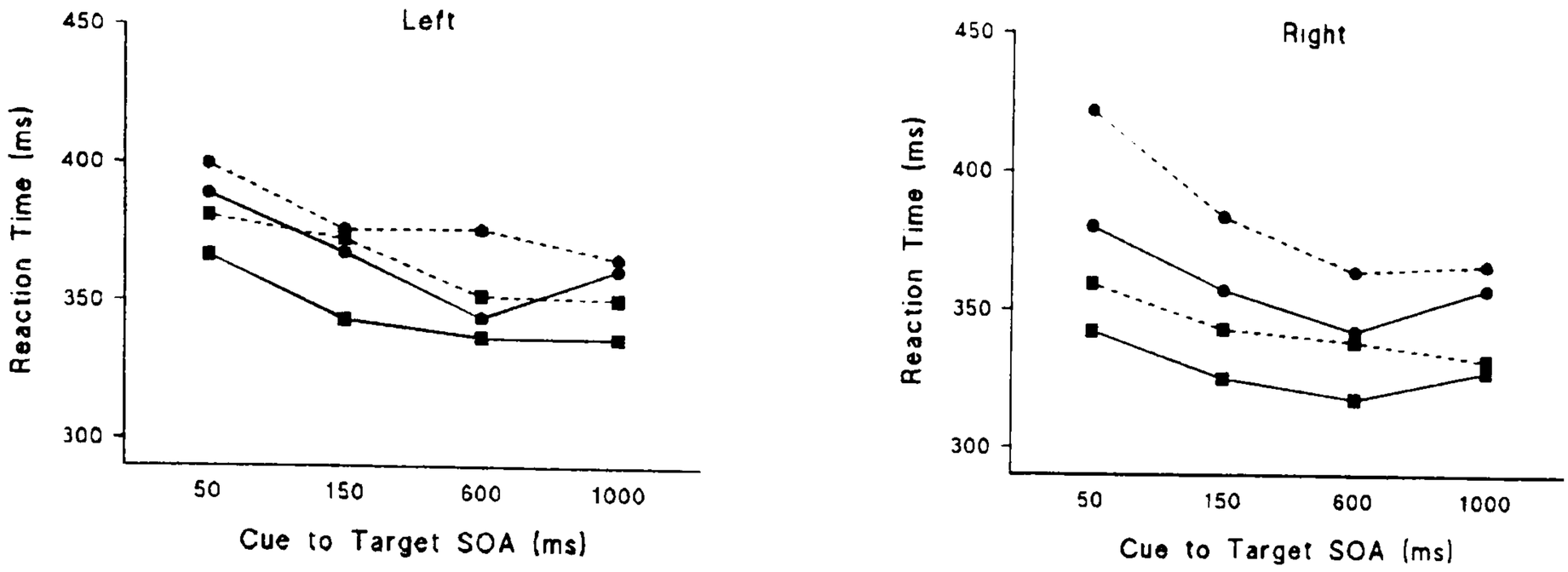


Figure 3.7.Mean Reaction times to targets occurring at varying intervals following a valid or invalid cue for both autism and comparison groups in Experiment 3. The left graph shows RT to targets occurring in the left visual field. The right graph shows RT to targets occurring in the right visual field; ● Autism group valid cue; --- ● ---Autism group invalid cue; ■ Normal group valid cue; --- ■ ---Normal group invalid cue;

These data were compared using ANOVA with a between subject factor of Group (Autism/Normal) and within subject factors of Cue (Valid/Invalid/Neutral), SOA (50, 150, 600 and 1000ms) and Visual Field (Left/Right). There were no significant differences between the two groups [$F(1,30)=2.09$, $p=0.16$]. There were significant effects of Cue [$F(2,60)=27.42$,$p=0.001$], SOA [$F(3,90)=18.96$, $p=0.001$] and Visual Field [$F(1,30)=7.39$, $p=0.01$]. Finally there was a Visual Field by Group interaction [$F(1,30)=7.39$,$p=0.01$]. Simple effect tests revealed that this interaction was attributable to a significant effect of Visual Field for the comparison group [$Fs(1,30)=11.46$, $p<0.01$] but not for the group with autism [$Fs(1,30)<1$,ns] and a significant effect of Group for the right visual field [$Fs(1,30)=3.85$, $p<0.05$] but not the left visual field [$Fs(1,30)<1$,ns]. All other interactions were not significant (Cue by Group [$F(2,60)<1$,ns], Cue by SOA [$F(1,30)= 2.12$, $p=0.09$],

Cue by SOA by Group [F(6,180)=0.37, p=0.89], Cue by Visual Field [F(2,60)=0.85, p=0.28],Cue by Visual Field by Group [F(2,60)= 0.85, p=0.43], SOA by Visual Field [F(3,90)= 0.94, p=0.43], SOA by Visual Field by Group [F(3,90)= 0.51, p=0.67], Cue by SOA by Visual Field [F(6,180)=0.58, p=0.75] and Cue by SOA by Visual Field by Group [F(6,180)=0.70, p=0.65]). Table 3.5 shows the mean RT of both groups for the valid and invalid trials and the validity effect which is the difference between the RT to an invalid cue and a valid cue for the left visual field only. Table 3.6 shows a comparison of the validity effect of each group for the right visual field.

Table 3.5. Validity effects in Experiment 3. A comparison of the mean RT at each SOA for valid and invalid trials of each group in the left visual field.

Left Visual Field

	Autism			**Normal**		
SOA	Valid	Invalid	Validity Effect	Valid	Invalid	Validity Effect
50	389.00	399.84	+10.84	366.68	381.09	+14.41
150	367.09	375.44	+8.35	343.00	372.09	+29.09
600	343.47	375.13	+31.66	336.44	351.25	+14.81
1000	360.69	364.53	+3.84	336.03	350.00	+13.97

Table 3.6. Validity effects in Experiment 3. A comparison of the mean RT at each SOA for valid and invalid trials of each group in the right visual field.

Right Visual Field

	Autism			**Normal**		
SOA	Valid	Invalid	Validity Effect	Valid	Invalid	Validity Effect
50	380.25	421.97	+41.72	342.25	359.37	+17.12
150	357.31	383.84	+26.53	325.25	343.19	+17.94
600	342.66	364.31	+21.65	317.75	338.84	+21.09
1000	358.25	366.97	+8.72	327.94	332.28	+4.34

To examine the validity effect the mean of the RT scores of the valid trials were subtracted from the invalid trials at each of the SOAs. These were compared using ANOVA with a between subject factor of Group (Normal/Autism) and a within subject factors of SOA (50,150,600 and 1000ms) and Visual Field (Left/Right). This analysis revealed no significant differences between the two groups [$F(1,30)=0.14$, $p=0.71$]. There were no significant main effects of SOA [$F(3,90)=2.62$, $p=0.07$] or Visual Field [$F(1,30)= 0.75$, $p=0.40$]. All other interactions were not significant (SOA by Group [$F(3,90)=0.97$, $p=0.41$], Visual Field by Group [$F(1,30)= 2.24$, $p=0.14$], SOA by Visual Field [$F(3,90)=0.78$, $p=0.51$] and SOA by Visual Field by Group [$F(3,90)= 1.11$, $p=0.35$]).

Cost-Benefit Analysis

To examine the effect of the 'benefits' associated with orienting to a valid cue the mean of the RT scores of the neutral trials were subtracted from the mean of the valid trials. These

were compared using ANOVA with a between subject factor of Group (Normal/Autism) and within subject factors of SOA (50, 150, 600 and 1000 ms) and Visual Field (Left/Right). This revealed a significant effect of SOA [$F(2.41,90) = 3.275$, $p<0.035$ (Greenhouse-Geisser Epsilon corrected)]. There were no significant differences between the two groups [$F(1,30)= 1.56$, $p=0.22$]. All other main effects and interactions were not significant (SOA by Group [$F(3,90)= 0.26$, $p=0.85$], Visual Field [$F(1,30)= 2.69$,$p=0.11$], Visual Field by Group [$F(1,30)= 0.42$, $p=0.52$], SOA by Visual Field [$F(3,90)=0.91$, $p=0.44$] and SOA by Visual Field by Group [$F(3,90)= 0.2$, $p=0.99$. To examine the effect of the 'costs' associated with orienting to an invalid cue the mean of the RT scores of the neutral trials were subtracted from the mean of the invalid trials. These were compared using ANOVA with a between subject factor of Group (Normal/Autism) and within subject factors of SOA (50,150, 600 and 1000ms) and Visual Field (Left/Right). No significant results were found (SOA [$F(3,90)=0.57$, $p=0.64$], SOA by Group [$F(3,90)=0.17$, $p=0.92$, Visual Field, [$F(1,30)= 0.59$, $p=0.45$], Visual Field by Group [$F(1,30)= 0.34$, $p=0.56$], SOA by Visual Field [$F(3,90)=0.21$, $p=0.89$] and SOA by Visual Field by Group [$F(3,90)=0.89$, $p=0.45$]). Figure 3.8 shows the costs and benefits associated with orienting to a valid and an invalid cue. As there was no effect of visual field that dimension has been collapsed in the following figure.

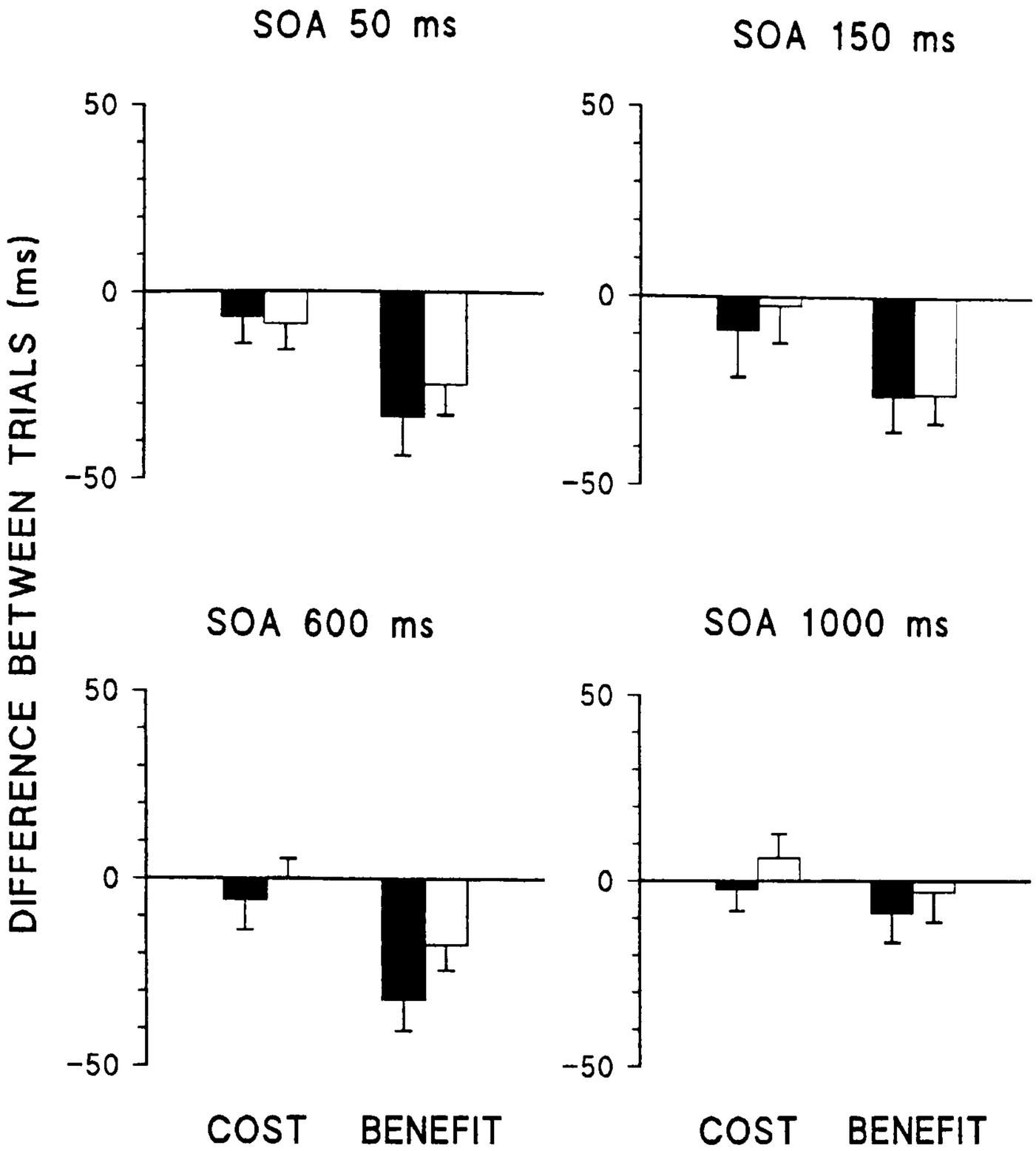


Figure 3.8. A comparison of the costs and benefits for both groups at each SOA in Experiment 3. ■ Autism group; □ Normal group.

Error Data

Anticipations

A small number of anticipatory responses i.e. RTs less than 100ms were excluded. These accounted for 0.8% and 1.6% of the responses from the comparison group and the group with autism respectively. There were no significant differences between the groups on this measure [$t(30)=1.87$, $p=0.08$].

False Alarms

The mean percentage of catch trials on which subjects incorrectly responded were calculated for each group. The comparison group produced a 'false alarm' response on

1.6% of trials in comparison with 2.6% for the group with autism. An independent sample t-test revealed no significant difference between the groups on this measure [t(30)= -1.17, p=0.25].

Misses

Of the remaining 384 trials the comparison group failed to make a response on only 0.1% of trials. The group with autism made 0.24% errors. Again this difference was not significant [t(30)=-0.78, p=0.44].

3.10 DISCUSSION

The results of Experiment 3 show that the individuals with autism have no impairment in their voluntary allocation of visual attention. Both groups showed comparable reaction times, validity effects and costs and benefits. The finding that the comparison group was faster to shift their attention to the right visual field than the left visual field possibly reflects the preponderance of right-handed participants in the sample studied (Carter, Krener, Chaderjian, Northcutt & Wolfe, 1995). This right field advantage was not present in this group in the previous two experiments perhaps reflects the fact that Experiment 3 involved investigation into voluntary attention whereas the previous experiments involved reflexive attention shifting. That this lateralized attentional difference was not present in the group with autism may lend support to the suggestion that language lateralization is less marked in this subject group (Dawson & Lewy, 1989).

The present pattern of results contrasts with those of the study by Wainwright-Sharp and Bryson (1993) who examined the performance of relatively high-functioning adolescents and young adults with autism using this type of paradigm at cue to target delays of 100ms and 800ms. The group with autism failed to show the normal RT advantage for validly cued targets at the shorter cue to target delay, indeed they failed to

show any effect of cue which suggests that they did not process the spatially informative cue. At the longer cue to target delay however, the individuals with autism showed a robust advantage of valid over invalid trials that was significantly greater than the comparison group. However, Wainwright-Sharp and Bryson go on to discuss that the particularly slow responses to the left field invalid trials is largely accounted for by the two left-handed participants in the group with autism. They also analyse the Group by Delay interaction by multiple t-tests, which runs the risk of making a Type 1 statistical error. Alternative explanations for the differences found between the groups in the Wainwright-Sharp and Bryson study could be an impairment in processing the central cue and/or a delay in motor response preparation and not to difficulties in the shifting of attention.

3.11 GENERAL DISCUSSION

The three experiments reported in this study were designed to investigate the hypothesised attentional impairments in autism. The first experiment examined the low level attentional mechanism 'inhibition of return' which is thought to act as a novelty bias which impedes the processing of stimuli or locations that have been previously attended to. This was deemed important given that individuals with autism show high perseveration on tasks like the WCST and engage in repetitive behaviour. However our evidence would suggest that this mechanism is intact in individuals with autism and provides further support for the position that inhibitory mechanisms are not contributing to their impaired performance on tasks of executive function (Ozonoff et al., 1994; Ozonoff & Strayer, 1997). There was however, some suggestion that the individuals with autism showed a reduced magnitude in reflexively shifting their attention in space at short cue to target delays.

Experiment 2 was designed to investigate this further by examining the differences between two types of neutral cue. There were no group differences between reaction times

following no cue or a double cue, suggesting that the reason for the small differences in the costs and benefits associated with cueing between the two groups found in Experiment 1 was not due to the fact that the group with autism found the double cue too alerting as hypothesised. Differing task demands and the possibility of carry over practice effects are possible candidates for the discrepancy between the two experiments. The results failed to replicate the overall reaction time and small cost and benefit differences found in Experiment 1 indicating no pervasive deficit in reflexively orienting attention among individuals with autism. Attentional orienting was further explored in Experiment 3, which examined voluntary attention shifting ability. As a group the individuals with autism were not slower in responding on the spatial reaction time task. Moreover, analyses designed to focus on the speed of attentional deployment did not reveal a selective deficit in the individuals with autism compared with the matched control group.

It is difficult to make direct comparisons between this study and those reported by Courchesne and colleagues and others reporting attentional problems in autism (Wainwright-Shape & Bryson, 1993; Casey et al., 1993) given the slight differences in task design, subject's ability and age range. However, when methodological problems are controlled for, well-matched control groups are used and larger numbers in each group are employed, no differences in either their relatively automatic or their voluntary allocation of visual attention are found.

CHAPTER 4

Visual Search

4.1 INTRODUCTION

While the weight of evidence reported in Chapter 2 would suggest that individuals with autism have difficulties shifting their attention, this proposal was not supported by the results of chapter 3. Moreover, in marked contrast to the evidence reporting disordered control over their attentional capabilities, a recent study by Plaisted, O'Riordan and Baron-Cohen (1998a) has reported that on tasks of visual search, individuals with autism performed at a superior level to that of age and verbal mental age matched control subjects.

Tasks of visual search require the subject to detect a target from an array containing varying numbers of distractors. If the target differs from the distracters in some simple property or feature, such as colour (e.g. a red X among green X's- feature search), the target is detected about equally fast in an array of 20 items as in an array of 6 items. Such targets pop out of the display, so that the time taken to find them is independent of the number of distracters. On the other hand, if a target is characterised only by a conjunction of properties (e.g. a red X among green X's and red O's - conjunctive search), the time taken to find the target or to decide that the target is not present increases linearly with the number of items in the display.

Strikingly, Plaisted et al. (1998a) found that children with autism showed no significant slowing in reaction time with set size in the conjunctive search task and were faster than the normally developing children. This result is particularly surprising as it would appear that visual search makes increased demands on the ability to shift attention

between stimuli as subjects must move their attention around a host of potential targets and not simply to a single target as in attentional cueing paradigms. Treisman and Gelade`s (1980) initial account of visual search performance suggests that in the conjunctive search condition subjects must serially focus their attention on each item in the display until the target is detected. More recently, Treisman and Sato (1990) and Findlay (1997) have suggested that several locations may be processed in parallel, but the need to move attention between clusters of stimuli (especially with larger display sizes) remains.

There are two possible explanations of the discrepancy between the results of this study and the literature on shifting attention. Plaisted et al. (1998a) suggest that the superior performance of the subjects with autism may reflect a superior ability to integrate information about individual stimuli and thus better discriminate between targets and distractors. However, this account is at odds with the evidence suggesting individuals with autism are poor at integrating information to form a gestalt and better able to focus on local details of a complex stimulus (Frith, 1989). A second possible explanation noted by the authors is that it may be that individuals with autism just have superior visuospatial skills and so have a performance advantage on a wide range of visuospatial tasks. A visuospatial advantage has also been proposed to explain the performance peaks of individuals with autism on the Block Design and Object Assembly tasks of the WAIS (Shah & Frith, 1983; Asarnow, Tanguay, Bott & Freeman, 1987). If this is the case, then it may be a confounding factor that the autistic children in the Plaisted et al. study had a significantly higher performance IQ than the control subjects. On this account, the superior performance of the group with autism might then reflect the importance of visuospatial ability to task performance rather than a characteristic of autism per se. Although Plaisted, O'Riordan and Baron-Cohen (1998a) do acknowledge this possibility, they point out that

there was no correlation between the block design test and the average RTs in the conjunctive search condition for each group.

The aim of the present study is to extend work on visual search in autism. Experiment 1 was designed to overcome some of the difficulties of the Plaisted et al. study by using (i) a bigger sample size, (ii) control subjects matched for chronological age, verbal and performance IQ, and (iii) a display density which was held constant across changes in display size. Palmer, Ames and Lindsay (1993) have suggested that sensory processes such as lateral masking or perceptual grouping may confound the measurement of attention in simple visual search tasks. Therefore alterations in stimuli density may serve to interfere with or facilitate perception. A group of adolescents and young adults were chosen as subjects because of difficulties encountered in a previous study (Neely, 1998) using the same task. The results of this study revealed no significant differences between the children with autism and a control group of typically developing children matched for chronological age, verbal and performance IQ. However, keeping children on task across a large number of trials was problematic and therefore reaction time data taken from a group of adults was deemed more reliable.

4.2 METHOD – Study 2

Experiment 1

Participants

Two groups of participants took part in this study: a group of sixteen high functioning adults with ASD (9 males, 3 females with Asperger's Syndrome and 2 males, 2 females with high-functioning Autism) and a comparison group of sixteen (11 males and 5 females) developmentally normal adults. Diagnostic criteria and ability assessment were as specified in Chapter 3. Participants' characteristics are shown in Table 4.1. Unpaired t-

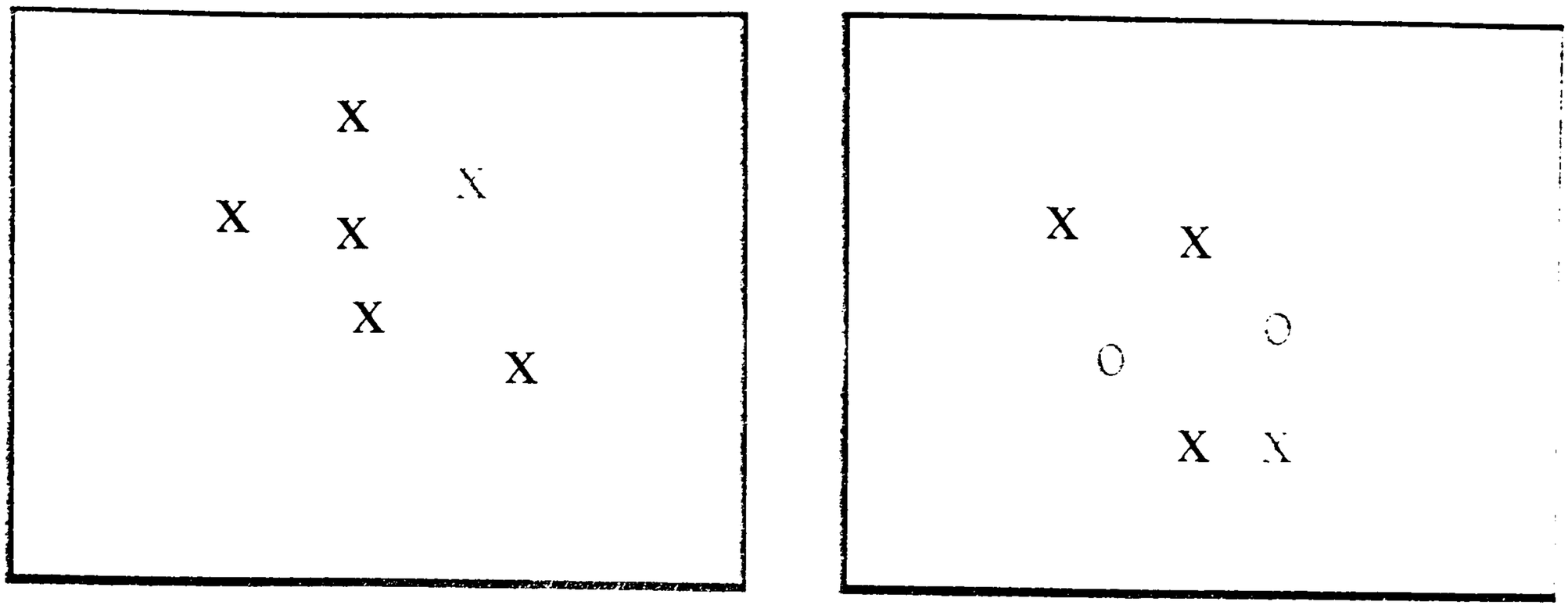
tests revealed that the chronological ages, VIQ, PIQ and IQ of the two groups were not significantly different ([t (28)= -0.06, p=0.95], [t (21)=0.64, p= 0.53],[t (31)= 1.03, p=0.31] and [t (27)=0.79, p=0.44] respectively). All participants had normal or corrected to normal vision. Three participants from the comparison group and two participants from the group with ASD were left-handed.

Table 4.1. Participant characteristics in Experiment 1.

Group	N		AGE(y:m)	VIQ	PIQ	overall IQ
Autism	16	Mean	20.6	88.6	85.5	86.8
		SD	2.31	14.4	14.5	13.7
		Range	16.3-24.2	72-120	72-112	72-113
Normal	16	Mean	20.6	91.13	90.09	90.12
		SD	1.85	6.72	15.00	9.72
		Range	17.0-25.0	76-101	75-128	75-123

Stimuli and Apparatus

Stimulus displays consisted of 6,10 or 20 letter characters arranged in an imaginary grid, randomly selected from a set of grid positions. The imaginary grid decreased in size from 16.4cm X 12.5cm (approximately 16° visual angle) in the 20 element condition to 12.4cm X 8.5cm (approximately 12° visual angle) in the 10 element condition to 9.6cm X 6.5cm (approximately 9° visual angle) in the 6 element condition. This reduction in size ensured that stimulus density remained constant across conditions. Viewing distance was approximately 57cm. Each element measured 0.5cm X 0.5cm subtending approximately 0.5° of visual angle horizontally and 0.5° vertically. The minimum distance between elements in any display were 0.5cm between positions in a row and 0.5cm between positions in a column. Display elements comprised two dimensions, colour (red and green) and shape (X and O). The stimuli were generated by a Texas Instruments Travelmate 6030 notebook computer and displayed on a 15-inch colour monitor. The computer recorded reaction time and error data. Subjects responded by pressing one of two buttons on a button box (the right button for the right hand signalling target present and the left button for the left hand signalling target absent). The buttons were reversed for left handed subjects; therefore participants responded 'target present' with their dominant hand. An example of the task is shown in Figure 4.1.



a b

Figure 4.1. The left figure (a) shows an example of a feature search, target present. The right figure (b) shows an example of a conjunctive search, target present. Black Xs represented green stimuli in the task. Grey Xs and Os represented red stimuli in the task.

Design

The experiment had a mixed design, with one between subjects factor of Group (Normal/Autism) and three within subject factors of Condition, Display size and Probe. The experiment comprised two search tasks (Condition), one for a feature target and one for a conjunctive target. Each search task contained two crossed factors: Display size (6,10 or 20 letters) and Probe (target present or absent), so that 6 combinations exhausted each experimental factor. There were 16 trials for each combination of factors yielding a total of 96 trials per condition. Trials were randomised in two blocks of 48 trials balanced for equal presentation of all experimental factors. In this way, each subject completed four blocks of 48 trials within the testing session. The order of target present and target absent trials and of different display sizes were randomised. The subjects performed a binary choice reaction time task in which search was conducted for a prespecified target (a red X). In the feature condition, non-targets differed from the target on one dimension - colour

(i.e. a red X among green X distracters). In the conjunctive condition each distracter shared one feature with the target (i.e. a red X among green X and red O distracters). The order in which the condition was presented (feature or conjunction) was randomised to counterbalance any order effects.

Procedure

Ability testing was carried out in sessions prior to the start of the experiment. For the search tasks, each participant was tested in a quiet room in his/her college. Each participant was tested on both the feature and conjunctive search tasks during one session. The participant was seated 57cm in front of the monitor and was told that they were helping to find out how quickly people could find a target when it was mixed up with other items. The participant was informed that the target was a red X. They were told that on some of the trials the target would be presented alongside green X's, some the target would be interspersed among green X's and red O's and on some of the trials the target would not be there at all. If the target was present, they were to respond by pressing the right button and if the target was absent they were to respond by pressing the left button. For left handed participants this instruction was reversed, i.e. they were told to press the left button if the target was present and the right button if the target was not present. Participants were asked to keep their index fingers poised over these buttons at all times. They were instructed to respond as quickly as possible with as few mistakes as possible and were encouraged to stare at the middle of the screen. Eye movements were uncontrolled, as previous research using relatively large items spaced fairly widely to limit peripheral crowding effects (Levi, Klein & Aitsebomo, 1985) has obtained the same pattern of reaction time data regardless of the presence or absence of eye movements (Klein & Farrell, 1989). The display remained in view until the participant responded. The

next display appeared 500ms after the response. Each session was split into four blocks of 48 trials. After each block of trials participants were offered a short break of approximately 1-2 minutes.

Participants were given 12 search trials of both feature and conjunctive conditions before the start of the experiment. In addition to the participants reported in Table 1 two other participants were tested but had difficulty with the task requirements. One participant from the comparison group showed evidence of a speed accuracy trade off with extremely fast reactions times and a high error rate. He was not complying with the experimental instructions and his data were excluded from the analyses. One participant from the group with autism showed some evidence of a co-morbid tic disorder with excessive tics interfering with the reliability of his reaction time data therefore his data were excluded from the analyses.

4.3 RESULTS

Reaction Time

Figure 4.2 shows the mean RT data from both groups of subjects in each search task. The left panel shows the pattern of results for the comparison group. RT for the comparison subjects to detect the feature target showed minimal effects of the display size with RT increasing non-linearly as the number of distracters increases. In contrast, RT for the comparison subjects to detect the conjunctive target increased linearly with display size. Overall RT was much slower in the conjunctive condition than the feature conditions. The right panel shows the pattern of results for both search tasks for the group with autism. Both groups were slower in the conjunctive condition than in the feature condition with the slope for absent responses steeper than that for present responses. That is, there was a much more marked effect of the display size when the target is absent than present.

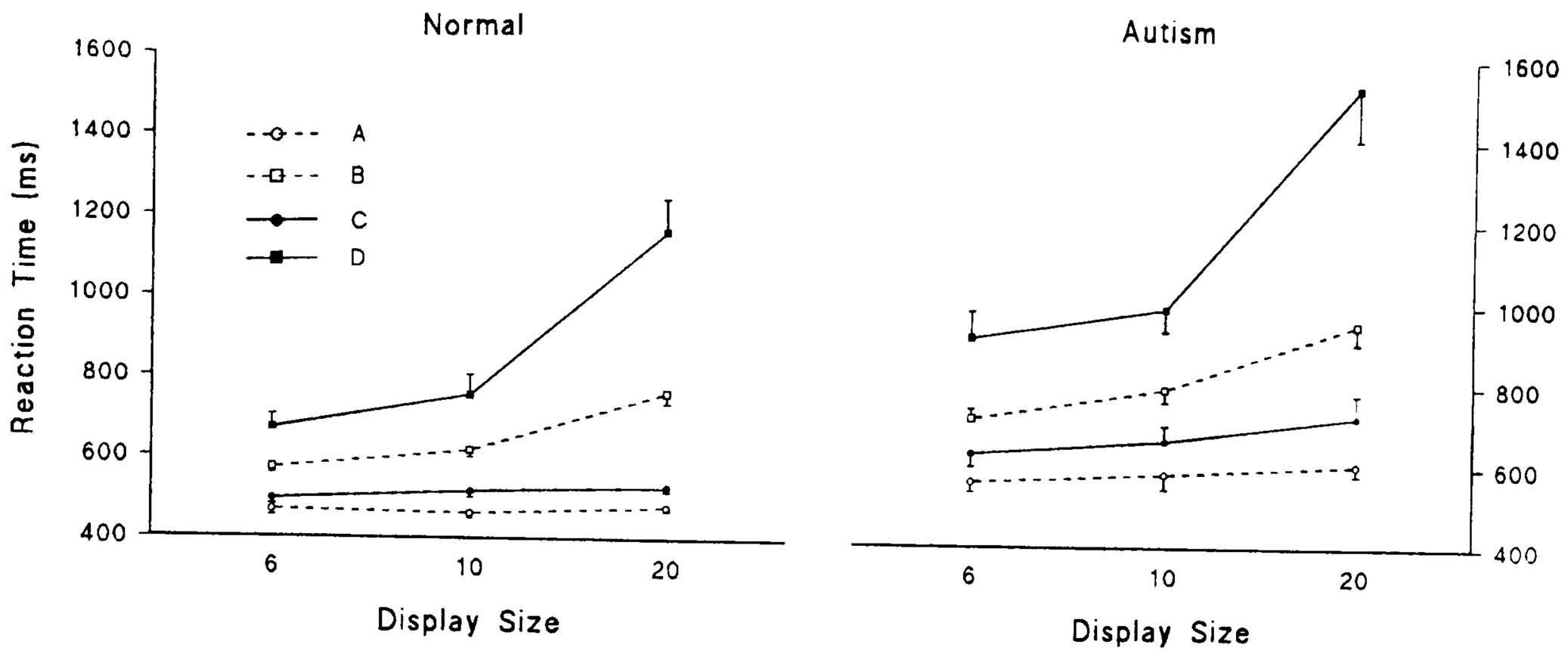


Figure 4.2. RT (mean +SEM) in visual search tasks for control subjects (N=16) and subjects with autism (N=16) in Experiment 1. A. Feature present condition; B. Conjunctive present condition; C. Feature absent condition; D. Conjunctive absent condition. The left graph shows the RT data for the comparison group whereas the right graph shows the RT data for the group with autism.

The mean RT scores were analysed using ANOVA with a between subject factor of Group and within subjects factors of Condition (feature or conjunctive), Probe (target present or target absent) and Display Size (6, 10 or 20 items). This revealed significant main effects of Condition, [$F(1,30) = 200.47$, $p<0.001$]; Probe, [$F(1,30) = 55.67$, $p<0.001$]; and Display Size, [$F(2,60) = 113.59$, $p<0.001$], indicating faster reaction times in the feature condition, faster reaction times on target present trials and longer reaction times with increasing display sizes. The group with autism were overall significantly slower [$F(1,30)= 17.36$, $p<0.001$.

The Group by Condition interaction was also significant [F (1,30) = 4.45, p<0.043]. Simple effects tests revealed that this interaction was attributable to a more significant effect of Condition for the group with autism [Fs(1,30)= 132.31, p<0.01] than the comparison group [Fs(1,30) =72.60, p<0.01] and a more significant effect of Group for the conjunctive condition [Fs(1,30) = 55.47, p<0.01] than the feature condition [Fs(1,30)= 19.95, p<0.01]. This pattern of results suggests that whilst the subjects with autism were slower overall, this difficulty was most marked in the conjunctive condition.

The remaining interaction terms involving the between subjects factor of Group were non-significant (Group by Probe [F(1,30) = 3.26, p=0.08], Group by Size [F(2,60)= 2.98, p=0.06], Group by Condition by Probe [F(1,30)=1.21, p=.28], Group by Condition by Size [F(2,60)=0.73, p=0.49], Group by Probe by Size [F(2,60)=1.85, p=0.17] and Group by Condition by Probe by Size [F(2,60)=0.52, p=0.60]). However, four further interaction terms were found to be significant replicating standard visual search performance. The Condition by Display Size interaction was found to be significant [F(2,60)= 126.08, p<0.001]. Simple effects tests revealed that the source of this interaction was a significant effect of Size for the conjunctive condition [Fs(2,60)= 183.44, p<0.01] but not for the feature condition [Fs(2,60)= 2.43, p>0.05] and significant effects of condition for increasing display sizes (6 element size [Fs(1,30) = 22.59, p<0.01], 10 element size [Fs(1,30)= 37.55, p<0.01] and 20 element size [Fs(1,30)= 186.13, p<0.01]. Therefore an increase in display size slowed performance to a greater extent in the conjunctive condition than in the feature condition.

The Probe by Display Size interaction was also significant [F(2,60) = 45.23, p<0.001]. Simple effect tests revealed a more significant effect of Size for absent trials [Fs(2,60)= 119.93, p<0.01] than for present trials [Fs(2,60)= 17.14, p<0.01] and a significant effect of Probe for increasing display sizes (6 element size [Fs(1,30)=6.42,

p<0.05], 10 element size [Fs(1,30)= 9.15, p<0.01] and 20 element size [Fs(1,30) = 54.25, p<0.01]). Therefore an increase in display size slowed responding to a greater extent in target absent trials than target present trials.

The Condition by Probe interaction was also found to be significant [F(1,30) = 42.35, p<0.001]. Simple effect tests revealed that there was a significantly greater effect of Probe in the conjunctive condition [Fs(1,30)=71.25, p<0.01] than the feature condition [Fs(1,30)= 4.45, p<0.05] and a greater significant effect of Condition for absent trials [Fs(1,30)=175.78, p<0.01] than present trials [Fs(1,30)=45.77, p<0.01]. These results indicate that RT is slowed in target absent trials more in the conjunctive condition than in the feature condition.

Finally there was a significant Condition by Probe by Display Size interaction, [F(2,60)= 38.12, p<0.001]. Two separate ANOVAs were conducted for each condition which revealed a significant Probe by Display Size interaction in the conjunctive condition [F(2,60)= 54.24, p<0.001] but not the feature condition F(2,60)=1.58, p=0.21]. Combined with the results mentioned above, this indicates that RT was significantly higher in the conjunctive condition, was higher on absent than present trials and was higher with larger display sizes.

Relationship between RT and ability

Mean RTs across both condition of the task were calculated for each group. Pearson's correlation coefficients were then calculated to examine the relationship between overall RT and VIQ, PIQ and full scale IQ for each group. These analyses revealed no significant pattern of association between reaction time and ability for either the group with autism [mean RT and VIQ: r= –0.31, ns; PIQ: r=-0.21, ns; FSIQ: r=-0.30, ns] or the comparison group [mean RT and VIQ: r=-0.16, ns; PIQ: r=-0.37, ns; FSIQ; r=-0.32, ns].

Error data

For both groups, rates of errors were low with the subjects with autism making on average 2.84% errors and the comparison subjects making 2.44% errors. The mean error scores were analysed using ANOVA with a between subject factor of Group and within subject factors of Condition and Probe. There were no significant differences in the overall rate of errors for the two groups [$F(1,30) < 1$, ns]. However, there was a significant Condition by Group interaction [$F(1,30)=4.59$, $p<0.04$]. Simple effects revealed that the group with autism produced significantly more errors in the conjunctive condition than the feature condition [$Fs(1,30)= 8.64$, $p<0.05$] but there were no such significant difference between conditions for the comparison subjects [$Fs(1,30)<1$, ns]. This analysis also revealed a significant main effect of Condition [$F(1,30) = 4.06$, $p<0.05$], reflecting higher rates of error for the conjunctive condition (3.16%) than the feature condition (2.11%), and a significant main effect of Probe [$F(1,30)= 32.15$, $p<0.001$], indicating a greater rate of errors in the target present condition (3.87%) than in the target absent condition (1.4%). All remaining interaction terms were found not to be significant.

Relationship between reaction time and error rate

Pearson's correlation coefficients were calculated to examine the relationship between reaction time (mean RT across conditions) and overall rate of errors for each group. These analyses revealed no evidence of a speed-accuracy trade off for either group [autism: $r = 0.30$, ns; control: $r = 0.05$, ns]. Therefore, any differences between groups can be taken to reflect differences in visual search rather than differences in detection criteria between groups.

4.4 DISCUSSION

Results from Experiment 1 show that the individuals with autism displayed significantly longer reaction times than the control group when searching for a target and this deficit was most marked in the conjunctive condition. These results are in marked contrast to the study by Plaisted et al. (1998a), in which the children with autism were significantly faster than the normal control group in the conjunctive search task, with no linear increase in reaction time with increasing set size. No group differences were found in the feature search condition. These authors suggest that the absence of a linear increase in RT in the conjunctive search condition for the children with autism may reflect a superior ability in target-distracter discrimination. Plaisted et al. (1998a) also suggest that faster target detection in conjunctive search tasks among individuals with autism may be related to the superior performance of individuals with autism on the embedded figures task (Jolliffe & Baron-Cohen, 1997: Shah & Frith, 1983).

An alternative explanation for the faster reaction times shown by the children with autism may be that these subjects had a higher spatial IQ than the developmentally normal children. Acknowledging this possibility, the authors suggest that these results be regarded as preliminary until replicated with groups of children matched on a measure of general IQ. Whilst a higher spatial IQ may be consistent with faster reaction times, it is not clear how this might explain the absence of slope in the search function of the group with autism in the conjunctive condition.

In the present study, both groups showed the typical pattern of response in standard visual search tasks. In the feature search task, reaction time to detect the target showed minimal effects of display size. Active attention has been suggested not to play a part in a feature search since when the target is distinct from the distracters in one simple property, colour, it should 'pop out' of the display (Treisman & Gelade, 1980). In the conjunctive

search task, reaction time to detect the target or to decide that the target is not present increased linearly with the number of distracters. The search time in target absent trials increased at more than twice the rate of the search time in target present trials with increasing display sizes, which would imply that search was serial and self terminating (Treisman & Gelade, 1980).

While the subjects with autism were slower to detect the target overall, this difficulty was most marked in the conjunctive condition. This deficit could be consistent with reports of difficulties disengaging and/or shifting attention in space (Wainwright-Sharp & Bryson, 1993, Casey et al., 1993). However, an attention shifting impairment account would predict that the individuals with autism would show increasing difficulties with increasing set size in the conjunctive search task. This pattern of results was not found.

These results could be consistent with those reporting difficulties in the adjustment of the 'attentional lens' in autism (Burack, 1994). In order to maintain stimulus density, the size of the imaginary grid was expanded and contracted with the number of stimuli in the display. It is possible therefore, that the individuals with autism were having difficulty adjusting the attentional lens accordingly. This would account for the overall reaction time differences in the conjunctive search task, however this explanation cannot account for the overall differences in reaction time on the feature search in the individuals with autism, as active attention is generally assumed not to play a part in a simple feature search.

That the individuals with autism were slower in both search tasks raises the possibility that some other more general aspect of the task was posing difficulties for the subjects with autism. The demands of a visual search task requires subjects to hold in mind the nature of the target, scan the display looking for a match of this template and then make the appropriate response when the decision has been reached as to whether the target

is present or not. In this way, poor performance could stem from difficulties in perception, a reduced ability to hold in mind the nature of the target, an inability to conduct an appropriate and efficient search or, at a more basic level, a deficit in making a final decision and executing the appropriate response.

Experiment 2 was designed to investigate the possibility that impaired response selection and execution might underlie the performance deficit shown by the group with autism. This experiment compared the performance of the individuals with autism and the matched control group when given only one response option (target present). Evidence from the dyslexia literature (Nicolson & Fawcett, 1994a) has shown that dyslexic subjects were unimpaired on simple reaction time tasks, however deficits in performance were observed in a selective choice reaction time task. As there is now increasing evidence that a cerebellar dysfunction may contribute to the difficulties experienced by both dyslexic and autistic children (Nicolson et al., 1999; Fawcett & Nicolson, 1999; Nicolson & Fawcett, 1994b; Fawcett, Nicolson & Dean, 1996; Yap & Van der Leij, 1994), we wished to explore the possibility that response selection deficit may underlie the poor performance of the autistic group. Although the cerebellum has traditionally been viewed as essential for the control and integration of motor activity (Holmes, 1939; Hallett, Shahani & Young, 1975), recent years have seen claims that the cerebellum contributes to higher mental function (Leiner, Leiner & Dow, 1986, 1993; Canavan, Sprengelmeyer, Deiner & Homberg, 1994;Schmahmann, 1991;Gao et al., 1996;Bracke-Tolkmitt et al., 1989; Akshoomoff & Courchesne, 1992; Kim, Ugurbil & Strick, 1994; Middleton & Strick, 1994)). Given the evidence for cerebellar abnormalities in autism (e.g. Courchesne et al., 1994), it was predicted that this manipulation would be especially advantageous for the subjects with autism.

4.5 METHOD

Experiment 2

Participants

Fifteen participants from each group who took part in the visual search task were available for re-testing approximately six weeks later. Unpaired t-tests revealed that the chronological age, VIQ, PIQ and overall IQ of the two groups were not statistically different ([t (28) = -0.05, p=0.89], [t (28)=-1.54, p=0.134], [t (28)= -1.27, p=0.215] and [t (28)=-0.57, p=0.57]) respectively.

Stimuli and Apparatus

The stimuli and apparatus were identical to the previous experiment with the exception of the response box. Subjects in this experiment responded by pressing the button on a single button box signalling target present.

Design

The experiment had a mixed design with one between factor of Group (Normal/Autism) and within subject factors of Condition (Feature/Conjunctive) and Size (6,10,20). All other aspects of the design were identical to the previous experiment except that subjects only responded when the target was present.

Procedure

The procedure was similar to Experiment 1 except for a slight change in the experimental instructions given to participants. In this experiment participants were asked to press the button on the response box as quickly as possible if the target (red X) was present in the display. They were told that the next trial would appear 500ms following their response.

They were told not to press the button if the target was not present in the display, the display would simply remain on the screen for 2 sec, followed by the next trial. None of the participants had any difficulty with the task requirements.

4.6 RESULTS

Reaction time

Table 4.2 shows the mean RT data from both groups of participants in each search task. Figure 4.3 displays the mean RT data as a function of the experimental design. RT for all subjects to detect the feature target showed minimal effects of display size. In contrast, RT for all subjects to detect the conjunctive target increased linearly with display size.

Table 4.2. Mean (SD) reaction times in Experiment 2.

	Autism		**Normal**	
Size	**Feature**	**Conjunctive**	**Feature**	**Conjunctive**
6	490.73	615.53	417.67	506.27
	(71.96)	(87.67)	(54.03)	(53.84)
10	489.93	668.53	411.13	550.07
	(68.61)	(90.26)	(52.01)	(50.60)
20	543.00	846.80	438.53	689.07
	(59.97)	(130.32)	(53.59)	(72.21)

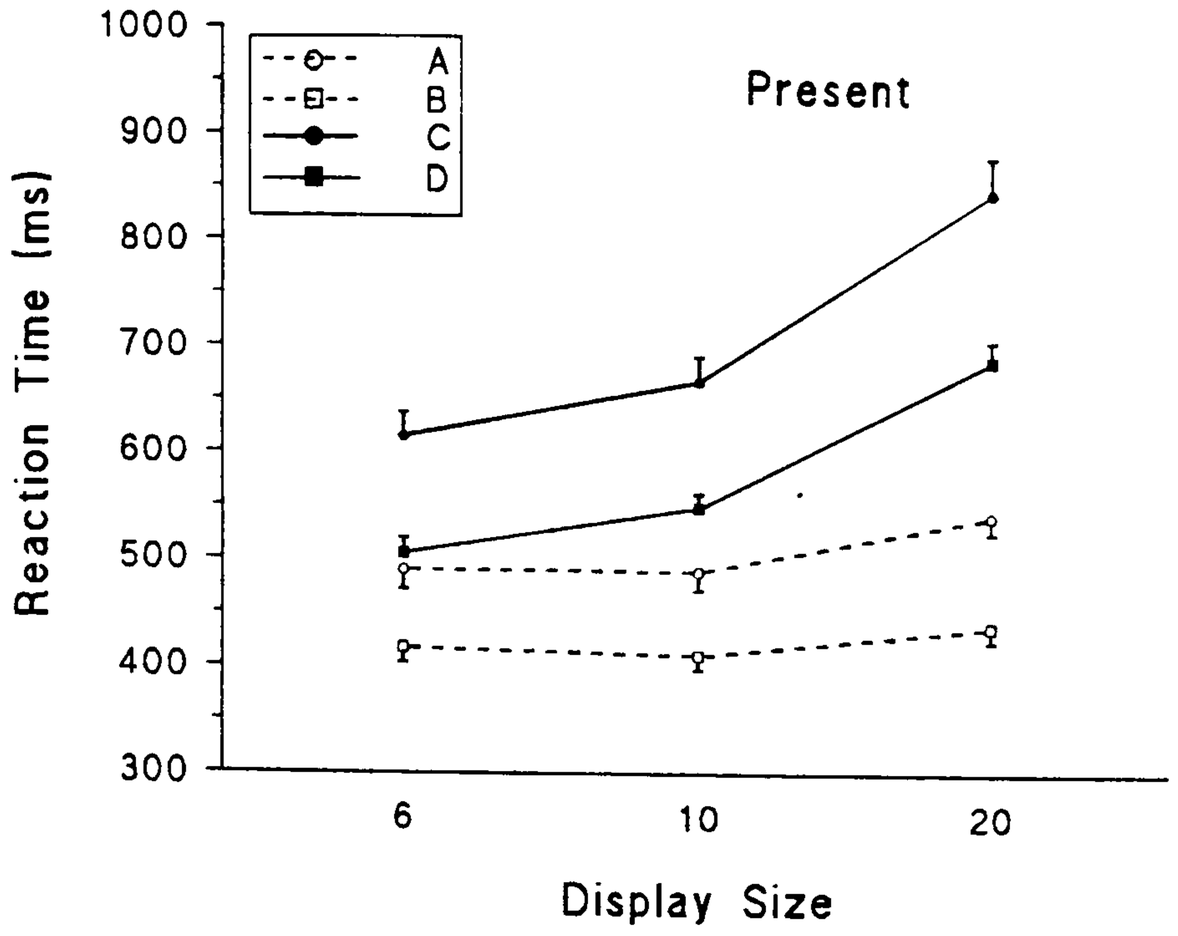


Figure 4.3. RT (mean +SEM) in visual search task (target present) for control subjects (N=15) and subjects with autism (N=15) in Experiment 2. A. Autism group Feature Condition; B. Control Feature Condition; C. Autism group Conjunctive Condition; D. Control Conjunctive Condition.

The mean RT scores were analysed using ANOVA with a between-subjects factor of Group and within-subjects factors of Condition and Display Size. This revealed a significant effect of Group [F (1,28)=26.95,p=0.001] indicating that the RT of the group with autism was overall significantly slower. The Group by Size interaction was also significant [F(2,56)=4.11, $p<0.02$]. Simple effect tests revealed a significantly greater effect of Group for increasing display sizes (6 element size [Fs(1,28)= 6.53, $p<0.05$], 10 element size [Fs(1,28)= 7.64, $p<0.05$] and 20 element size [Fs(1,28)= 13.49, $p<0.01$] and a significantly greater effect of Size for the group with autism [Fs(2,56)= 103.93, $p<0.01$] than the control group [Fs(2,56)= 53.67, $p<0.01$].

There was also a significant main effect of Condition [F (1,28)=177.27, $p<0.001$]; showing faster RTs in the feature than the conjunctive condition, and a significant main

effect of Size [F(2,56)=153.48, p<0.001] indicating that RT was slowed with larger display sizes. The Condition by Size interaction was also found to be significant [F (2,56)= 112.55, p<0.001]. Simple effect tests revealed that the source of this interaction was attributable to a more significant effect of Size for the conjunctive condition [Fs (2,56)= 214.11, p<0.01] than the feature condition [Fs(2,56)=9.03, p<0.01] and a greater significant effect of Condition for increasing display sizes (6 element size [Fs (1,28)= 20.56, p<0.01], 10 element size, [Fs(1,28)= 45.53, p<0.01] and 20 element size [Fs(1,20)= 138.75),p<0.01]. Therefore an increase in display size slowed performance to a greater extent in the conjunctive condition than in the feature condition.

The Group by Condition interaction [F(1,28)= 2.51, p=0.12] and the Group by Condition by Size interaction [F(2,56)=0.3, p=0.74] all failed to reach significance.

Comparing performance on the binary and single choice paradigms

To further explore the effect of employing a single choice paradigm, a difference score was calculated by subtracting the mean RT for each participant in each condition in the simple RT task (Experiment 2) from the comparable mean RT in the binary choice task (Experiment 1). Table 4.3 shows the mean difference score for each group and each condition at each display size.

Table 4.3. Mean paired differences between RT in Experiment 1 and Experiment 2.

	Autism		Normal	
Size	**Feature**	**Conjunctive**	**Feature**	**Conjunctive**
6	76.20	109.47	40.13	60.47
10	92.73	133.80	42.73	64.60
20	67.93	120.07	36.20	56.87

From this table it can be seen that the difference scores for the group with autism are notably greater than the comparable scores for the control subjects. This is particularly noticeable in the conjunctive condition where the difference scores of the subjects with autism are approximately double that of the comparison subjects.

Figure 4.4 shows a comparison of the mean RT data of both groups for target present trials in both experiments.

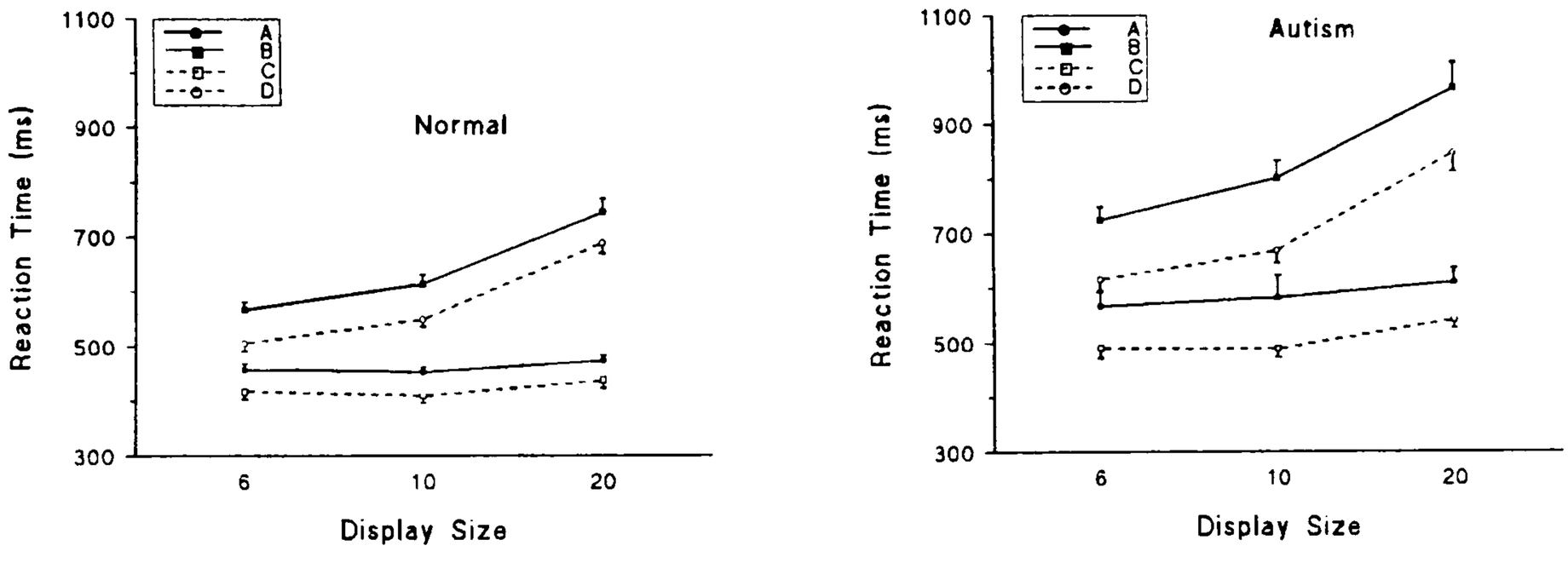


Figure 4.4.RT (mean +SEM) in visual search tasks for the control subjects (N=15) and subjects with autism(N=15). A. Feature Visual Search (Exp 1), B. Conjunctive Visual Search (Exp 1), C. Feature Target Present (Exp 2), D. Conjunctive Target Present (Exp 2).

The left panel shows the pattern of results for the comparison group and the right panel shows the results from the group with autism. These data were analysed using ANOVA with a between subject factor of Group and within subject factors of Test (Experiment 1 versus Experiment 2), Condition (feature versus conjunctive) and Size (6, 10 or 20). This analysis revealed that both groups had faster reaction times in Experiment 2 [$F(1,28)= 44.03$, $p=0.001$], however the group with autism were still significantly slower than the control group [$F(1,28)= 30.94$, $p=0.001$]. The significant result of interest was a Test by Group interaction [$F(1,28)=4.85$, $p<0.03$]. Simple effect tests indicated that the this interaction was attributable to a more significant effect of Group for Experiment 1 (binary choice reaction time) [$F(1,28)= 21.87$, $p<0.01$] than Experiment 2 [$F(1,28)= 10.17$, $p<0.01$] and a more significant effect of Test for the group with autism [$F(1,28)=39.06$, $p<0.01$] than the control group [$F(1,28) = 9.82$, $p<0.01$].Thus, the individuals with autism showed a greater improvement in performance between Experiment 1 and Experiment 2.

All other results simply replicated the effects described in Experiment 1 (significant main effects of Condition [$F(1,28) = 436.75$, $p=0.001$]; Size [$F(2,56)= 138.55$, $p=0.04$]; Group by Condition [$F(1,28)=8.13$, $p<.008$]; Group by Size [$F(2,56)=3.95$,$p<.04$); and Condition by Size $F(2,56)=120.78$, $p<.001$]). All other effects failed to reach significance (Test by Condition [$F(1,28)=3.58$, $p=0.07$], Group by Test by Condition [$F(1,28)=0.40$, $p=0.53$], Test by Size [$F(2,56)=0.84$, $p=0.44$], Group by Test by Size [$F(2,56)=0.31$, $p=0.74$], Group by Condition by Size [$F(2,56)=0.70$, $p=0.50$], Test by Condition by Size [$F(2,56)=0.12$, $p=0.89$] and Group by Test by Condition by Size [$F(2,56)=0.11$, $p=0.89$]).

Error data

Error rates were extremely low in both groups with only one subject in the comparison group and seven subjects in the group with autism making one error each (0.04% of trials for the control subjects and 0.63% of trials for the group with autism). Given this very low rate of errors, no further analyses were undertaken.

4.7 DISCUSSION

The results of Experiment 2 are broadly consistent with the hypothesis that an impaired ability to make and execute the appropriate response was contributing to the impaired visual search performance of the individuals with autism. When the demands of the task were reduced to require a single response, the performance of the group with autism improved to a greater extent than the comparison group. Moreover, the significant Group x Condition interaction found in Experiment 1 was no longer apparent indicating that the group with autism were no longer relatively more impaired on the conjunctive search condition. This pattern of results is consistent with recent findings in the dyslexia literature (Nicolson & Fawcett, 1994a) and may reflect cerebellar abnormalities in both groups. There is evidence for cerebellar pathology in autism (Courchesne et al., 1994) and traditionally the cerebellum is viewed as essential for the control and integration of motor activity (Holmes, 1939; Hallett, Shahani & Young, 1975).

Alternatively, the amelioration of the deficits displayed by the autistic group in Experiment 1 could be due to a relatively greater practice effect for this group, or possible ceiling effects limiting the scope for improvement in the control subjects. Whilst this account is consistent with the overall improvement of the group with autism it would not necessarily predict a relatively greater amelioration of the autistic deficit in the conjunctive search condition. This would suggest that the findings of a greater deficit in the

conjunctive search condition among the group with autism in Experiment 1 is not very robust or alternatively that minimising the response demands ameliorate deficits on harder tasks to a greater extent in individuals with autism.

However, response selection impairment can only be part of the problem that individuals with autism are experiencing on these visual search tasks as the overall reaction time differences remained. Possible explanations will be explored in the general discussion.

4.8 GENERAL DISCUSSION

The results show that the group with autism was significantly slower in both search tasks, however the results of both groups replicated standard visual search performance. That is, reaction time for target detection in the feature search condition was independent of the number of distracters, compared to a linear increase in reaction time for a conjunctive search with increasing numbers of items in the display. While attentional impairments could account for the relatively greater deficit seen in the group with autism on a conjunctive search task in Experiment 1, this was not replicated in Experiment 2. Moreover, deficits in shifting attention during a visual search task would predict a greater slope for increasing display sizes in the conjunctive search condition. This pattern of results was not found, therefore these results do not support the notion of an attention shifting impairment in autism (Courchesne et al., 1994; Townsend et al., 1996; Wainwright-Sharp & Bryson, 1993). This supports the results reported in Chapter 3 where the subjects with autism and the matched comparison group showed comparable performances, indicating no difficulties in shifting visual attention either voluntarily or reflexively. However, other difficulties unrelated to attention shifting could arise when

completing a visual search task, including problems with perceptual grouping, memory, strategy use and decision-making.

That individuals with autism may have problems with perceptual grouping has been highlighted by the central coherence theory (Frith, 1989). This theory proposes that individuals with autism have a particular cognitive style whereby they fail to integrate separate threads of information into a more meaningful whole, focusing on local attributes while ignoring a global gestalt. Since the letters in the visual search tasks were randomly placed on the screen they were unlikely to have produced a global pattern. However, lack of central coherence has been seen both at a conceptual level (Langdell, 1978; Frith & Hermelin, 1969; Frith & Snowling, 1983) and a perceptual level (Happé, 1996; Jarrold & Russell, 1997). Therefore, problems with perceptual grouping could be contributing to their overall slower reaction times in the feature search condition.

Grouping problems could also contribute to search success on conjunctive searches. Alternatives to Feature Integration Theory (Treisman & Gelade, 1980) have been proposed to account for search efficiency that emphasise the degree of discriminability between the target and distracters as factors determining the search function slope (Duncan & Humphries, 1989). Wolfe, Frankel and Cave (1989) have suggested that a conjunctive search may be treated as two simple feature searches under some circumstances. This has been called guided search. Guided search means that the subject might be able to look at only the green X's, ignoring the red O's, while searching for the red X. In this sense, the figure ground pre-attentive process could be used to group all distracters that can be ruled out on the basis of a simple feature and rejected, leaving only a second simple search to complete. While the display density was kept constant across display sizes to minimise the possible confounding effect of perceptual grouping in this study, a more direct way of assessing problems in this area would be to manipulate the degree of target and distracter

discernment. Predictions based on a lack of central coherence would suggest that individuals with autism would show a greater steepness of the RT slope across display sizes when target-distracter discriminability was decreased.

Difficulties with strategy use are another possible contender for impaired performance on visual search tasks. Findlay (1997) has also questioned the need for an item-to-item selection in conjunctive visual search as proposed by Feature Integration Theory (Treisman & Gelade, 1980). Findlay (1997) investigated saccade target selection during conjunctive visual search tasks. He has suggested that not all positions in peripheral vision are equivalent and that several search locations can be processed in parallel. This raises the possibility that some form of strategy may be useful in visual search tasks especially with larger display sizes. Pashler (1987) has also suggested that using a grouping strategy; smaller arrays can be searched in parallel for both features and conjunctions. That subjects with autism have a problem with the use of strategy has been demonstrated in their poor performance on tasks such as the Tower of Hanoi (or other closely related measures, such as the Tower of London; Shallice, 1982)(Ozonoff, Pennington & Rogers, 1991; Ozonoff & McEvoy, 1994; Hughes et al., 1994), and the Milner Maze (Prior & Hoffman, 1990). Therefore, an alternative possibility that the subjects with autism are performing poorly on this task relates to an executive impairment in strategy use.

The results of Experiment 2 would suggest that making the appropriate response decision was contributing to their impaired performance on the visual search tasks. When the demands of the task were reduced to require a single choice instead of a binary choice the group with autism improved their performance to a greater extent than the comparison group. Alternative explanations for this result could be due to a ceiling effect in the normal group and/or greater practice effects among the group with autism.

Although it is difficult to rule out any of these possibilities, a more parsimonious explanation for the overall reaction slowing seen in both search tasks among the individuals with autism may reflect some more general arousal and/or processing impairment. The proposal that individuals with autism may have a deficit in their homeostatic arousal modulating system was first suggested by Hutt, Hutt, Lee and Ounsted, (1964) and was later expanded on by Ornitz and Ritvo (1968). Hutt et al. (1964) proposed that the child with autism is in a chronic state of over arousal whereas Ornitz and Ritvo (1968) modified this hypothesis to suggest that autism is characterised by fluctuations between states of over and under arousal. A processing impairment explanation would predict that individuals with autism would display generally slower responses on a simple reaction time task. This remains to be investigated.

In conclusion, the results reported in this chapter provide no evidence for attention shifting impairments in autism. However, deficits in orienting may become apparent when shifting attention dependent upon social cues. Recent research from the vision literature has established that orienting in the direction of seen gaze can arise in a fairly "mechanical" or automatic fashion in normal individuals in response to either cartoon faces (Friesen & Kingstone, 1998), eyes only (Driver et al., 1999) or both head and eye direction changes (Langton & Bruce, 1999). A more in-depth review of this evidence is reported in chapter 5.

CHAPTER 5

Social Attention

5.1 INTRODUCTION

The experimental chapters reported so far have explored the hypothesis that individuals with autism have impairments in shifting attention. No pervasive deficits were found. Although attention is important for successful performance on low-level tasks typically used in research on visual attention, in the real world, social interactions tax the ability to control and shift attention to a greater extent. Following the unpredictable ebb and flow of joint social exchange may pose the greatest challenge to attentional systems and it may be that individuals with autism only have difficulty with social attention leading to the particular and characteristic disruptions of cognitive functioning and failure to develop key socio-cognitive skills. This chapter begins with a review of recent research that has adapted traditional cueing paradigms to investigate social attention in typically developing individuals. The chapter progresses along the framework of Chapter 1 with a review of social attention at the biological, behavioural and psychological levels. Finally, the chapter concludes with a review of the earliest identified social impairment in autism; lack of joint attention behaviours. There is some suggestion from this evidence that shifting attention is only problematic when social cues are involved.

5.2 SOCIAL ATTENTION AT THE BEHAVIOURAL LEVEL

The significance of the direction in which another individual is directing their attention is important to many species. For example, animals use gaze to convey to

others the state of their emotional disposition (threatening or submissive). In addition, a sudden gaze aversion will often signify a significant environmental event such as the presence of a predator or a potential mate. In humans, direct gaze can express intimacy and attraction or alternatively threat and dominance. Moreover, the detection and response to another's gaze is also important during social interactions, where gaze functions as the regulator of turn-taking in conversation, expressing intimacy and exercising social control (Kleinke, 1986). Indeed, it has been suggested that humans may have evolved eyes with a greater contrast between iris and sclera precisely because of the added benefits of an enhanced gaze signal in terms of communication and cooperation (Langton, Watt & Bruce, 2000). In contrast, most animal species do not have a widely exposed white sclera surrounding a much darker iris, so that the direction of gaze will be relatively disguised. This might have evolved in order to deceive predators or prey or even fellow conspecifics competing for food.

5.3 SOCIAL CUEING STUDIES

While the vast literature on visuospatial orienting has aided our understanding on many aspects of attention, such research has recently been criticised by Driver et al. (1999) for its lack of ecological validity and social significance. Driver et al. (1999) suggest that mainstream attention researchers have entirely overlooked Brothers' (1990) dictum that the human brain is largely a social brain and have focused instead on non-social situations. Recent research from the visual attention literature has addressed this issue and proposed that visuospatial orienting can arise in response to a 'social' cue. Several studies have shown a strong cueing effect produced by the direction of seen gaze of a central face picture cue even when counter to intentions (Friesen & Kingstone, 1998; Driver et al., 1999; Langton & Bruce, 1999).

The first published account of social orienting was a study by Friesen and Kingstone (1998). Friesen and Kingstone (1998) modified the standard Posner cueing paradigm (Posner, 1980) so that subjects were presented with a schematic face as the central cue, whose eye direction pointed left, right or straight ahead. The adult subjects in this study participated in three target response tasks: detection, localization and identification. Despite the fact that they were told that gaze direction did not predict where the target would occur, subjects were fastest to respond to the target when the gaze was directed towards the target in all three conditions.

Friesen and Kingstone (1998) proposed that the facilitation effect produced by the gaze cue reflects the involvement of exogenous (reflexive) covert attention. Their conclusions were based on criteria such as: the cueing effect emerged rapidly (appearing at the shortest SOA of 105ms) (Cheal & Lyon, 1991), it occurred even though subjects were informed that the gaze cue did not predict the target location (Jonides, 1981), the cueing effect exhibited a relatively short time course (Müller & Rabbitt, 1989) and it was characterised by benefits at the cued location (valid cue RT faster than neutral cue RT) without costs at the invalid location (invalid cue RT = neutral RT) (Posner & Snyder, 1975). Similar results have been reported by Langton and Bruce (1999), using a digitised head stimulus, and Driver et al. (1999) who used a computerised face where the direction of the eye gaze was manipulated.

Although the pattern of results bears the hallmark of exogenous or reflexive orienting of attention, the attentional cue was presented centrally at fixation. Typically, central cues have been associated with voluntary attentional shifts to peripheral locations by predicting where the target will appear in the periphery whereas a non-predictive abrupt onset occurring at a peripheral location is assumed to produce a reflexive attentional shift. Friesen and Kingstone suggested the fact that

a non-predictive centrally presented gaze cue can initiate a reflexive shift of attention indicates that the human brain may be specialised to shift attention in response to gaze direction.

5.4 SOCIAL ATTENTION AT THE BIOLOGICAL LEVEL

Given the functional significance of the eyes, it is perhaps unsurprising that the existence of a functionally separate module dedicated to the perception of gaze has been speculated upon (Campbell, Heywood, Cowey, Regard & Landis, 1990; Perrett, Smith, Potter, Mistlin, Head, Milner & Jeeves, 1984; Perrett, Hietanen, Oram & Benson, 1992). Neuropsychological studies have provided evidence of a double dissociation between face recognition and gaze perception. Campbell et al. (1990) report evidence from a prosopagnosic patient K.D. who was relatively unimpaired in an eye-gaze discrimination task. The reverse pattern of results comes from a study by Perrett et al. (1992) who report on a patient who was impaired on gaze recognition tasks but only mildly impaired in the recognition of famous faces. While prosopagnosia is associated with lesions in ventral occipitotemporal cortex that are usually but not always bilateral (Benton, 1980; De Renzi, 1986), the exact extent and location of the lesions reported in these patients is unclear.

However, neuroimaging studies have recently highlighted a role for specific areas in the temporal lobes involved in gaze processing. The dissociation of the functional contributions of the superior temporal sulcus and lateral fusiform gyrus to face perception has been demonstrated in an fMRI experiment by measuring how selective attention to eye gaze direction and to face identity elicits different responses to faces in these regions (Hoffman & Haxby, 2000). In this experiment, subjects viewed static pictures of faces presented sequentially. In one condition, subjects had

to indicate whether the direction of gaze was the same as in the previous picture and in the other, subjects were required to indicate whether each picture was of the same individual as the previous picture. The results showed that selective attention to eye gaze elicited a stronger response in the superior temporal sulcus than selective attention to identity did. In contrast, selective attention to identity produced a stronger response in the lateral fusiform gyrus than selective attention to gaze did.

Comparative studies have also suggested that the superior temporal sulcus (STS) is important for coding information about eye gaze. Campbell et al. (1990) found that bilateral STS ablation in monkeys impaired accuracy at perceiving frontal eye gaze. Furthermore Heywood and Cowey (1992) found that the removal of this region of the monkey cortex impaired gaze direction discriminations but did not impair performance on other face processing tasks. However, Eacott, Heywood, Gross and Cowey (1993) reported that in addition to impairments in discriminating eye gaze deviations, the STS lesioned animals were also impaired on a task involving a two-choice discrimination between different groups of ASCII characters. They concluded that the deficits in processing eye gaze among monkeys with lesions of the STS were due to deficits in two-choice discrimination learning.

Despite this, the idea that the STS is important in eye gaze perception persists. Based on recordings from single cells in awake behaving monkeys, Perrett et al. (1992) found cells in this region of the temporal lobe to respond to eye gaze direction. However, those cells that were active when presented with a pair of eyes looking downwards also responded strongly when heads were directed downwards or when the body adopted a quadruped position.

Based on this evidence, Perrett and colleagues proposed the existence of a direction-of-attention detector (DAD), which is a hierarchically arranged mechanism

that analyses the direction of the eyes, head and body to determine where another individual is directing their attention. This process is assumed to be achieved by a network of inhibitory connections. While the eyes hold prime importance in this model, if for example the eyes are concealed or the face is viewed at a distance, the mechanism signals the direction of attention from the orientation of the head, or if this too is obscured, from the orientation of the body.

5.5 PSYCHOLOGICAL THEORIES OF THE ANALYSIS OF SOCIAL ATTENTION

Baron-Cohen (1994, 1995) also places particular emphasis on the eyes in his "mind-reading system" to account for the processes involved in social cognition. The mind-reading system comprises four components; the intentionality detector, the eye-direction detector (EDD), the shared attention mechanism (SAM) and the theory-of-mind mechanism (ToMM). The utility of the EDD serves to detect the presence of eyes and to measure whether the eyes are directed towards it or towards another object in the environment. This in turn feeds information to the SAM, which is an important mechanism involved in the development of a child's understanding of mental state concepts such as desire, belief, pretence. The ToMM is then able to combine this mental state knowledge thus permitting the child or adult to explain and predict another's behaviour.

While both these models place particular significance on eye gaze as a cue to the direction of another's attention, other evidence would suggest that the perception of another's attention relies more on the head than eye-gaze orientations or on some combination of the two. Anstis, Mayhew and Morley (1969) reported that the perceived direction of a looker's gaze strayed in the opposite direction to the turn of the head. Therefore if someone were staring directly at your face, with the head

oriented towards your right shoulder, you would perceive them as gazing somewhere near the left side of your nose. More recently, Maruyama and Endo (1983) showed that subjects' perception of gaze direction in schematic faces lay in the middle between the eyes' actual line of gaze and the orientation of the head. Their results also suggest that the head orientation plays a relatively greater role in the direction of social attention detection, as although the processing of gaze direction was influenced by head orientation, the perception of head direction was not influenced by the perception of the eye gaze direction.

More recently, Langton (submitted) has suggested that both head and eyes have an equally mutual influence on decisions concerning the direction of social attention. He adapted an interference paradigm to examine the relationship between head orientation and eye-gaze direction. In this study, subjects had to respond to either the head or eye direction, where on half of the trials the head and eye were directed to the same location and the other half of the trials the head and eyes pointed in conflicting directions both in the horizontal and vertical plane. In one block of trials subjects responded to the orientation of the head and tried to ignore the direction of eye gaze and in the second block of trials subjects responded to the gaze direction and were asked to ignore the orientation of the head. The results showed interference effects that were symmetrical in nature. Langton (submitted) concluded that head and gaze are mutually influential in social attention detection and that information derived from the orientation of the head plays a greater role in the processing of social attention direction than either Perrett et al.'s (1992) or Baron-Cohen's (1994) models predict.

In summary, this review has suggested that typically developed individuals are particularly attuned to the social signals of others. Indeed, it has been shown that

these social cues are difficult or almost impossible to ignore and responses occur in a reflexive manner. Furthermore, brain areas dedicated to the analysis of social cues have been proposed. However, a review of the evidence for lack of joint attention behaviours and gaze following in autism will show that individuals with autism are less sensitive to the attentional signals of others.

5.6 EVIDENCE FOR JOINT ATTENTION BEHAVIOURS IN AUTISM

The earliest social impairment yet identified in autism is seen in the failure of normal infant-mother joint attentional interactions. Joint attention has been defined both narrowly and broadly in the research literature. Narrowly defined the term joint attention refers to "looking where someone else is looking" (Butterworth, 1991, p223). For instance, an infant may notice that another person has turned their eyes or head in a certain direction and then follows suit, or an infant may move their eyes or head towards the direction that someone is pointing. The broader definition of joint attention includes these behaviours in addition to checking another person's face while playing, after the infant has pointed to something or in an ambiguous situation.

From observational studies, it appears that joint attention behaviours occur far less frequently in children with autism than in non-autistic control groups (Loveland & Landry, 1986; Landry & Loveland, 1988; Mundy, Sigman, Ungerer & Sherman, 1986; Sigman, Mundy, Ungerer & Sherman, 1986). However, a deficit in joint attention could be caused by an inability to shift or modulate attention or by an inability to use gaze direction or other social signals as a guide. If the former view is indeed correct, deficits in orienting attention among individuals with autism should not be specific to social stimuli. Predictions based on the latter view would suggest that individuals with autism have a specific deficit in attending to social stimuli.

In a study of home videotapes of one-year-old toddlers, Osterling and Dawson (1994) found that in addition to deficits in shared attention, toddlers with autism failed to orient to social stimuli (faces, speech) in their environment. In a subsequent study, Dawson, Meltzoff and Osterling (1995) showed that this failure to orient was not confined to social stimuli. Children with autism in this study were compared to a matched control group of children with Down's syndrome. They observed head turns in response to non-social stimuli (a musical jack-in-the-box played for six seconds and a rattle being shaken) and social stimuli (clapping hands and calling the children by name). The children with autism were impaired at orienting to all stimuli but this failure was more extreme for social stimuli.

Earlier work by Hermelin and O'Connor (1967) also reveal abnormal attention control in children with autism that is not specific to social stimuli. Children with autism and matched comparison groups were presented with two displays in a viewing box with visual fixation time and switches of attention being recorded. Between group comparisons revealed that the children with autism looked for longer at the facial stimuli than at other nonfacial stimuli. However, they also looked more briefly at all stimuli and also showed fewer switches of attention between one object and another than the control children. These studies suggest that the lack of joint attention behaviours and the abnormal patterns of eye gaze often reported in autism may derive less from an avoidance of social stimuli than from a more general attentional abnormality.

However, a more recent study by Swettenham et al. (1998) examined the frequency and distribution of attention shifts between social and non-social stimuli in a naturalistic setting. Three types of attention shifting were observed; between an object and another object, between an object and a person and between a person and

another person. The typically developing and non-autistic developmentally delayed infants shifted attention more frequently between an object and a person than between an object and another object or between a person and another person. In contrast, the infants with autism shifted attention between an object and another object more than any other type of shift and showed fewer shifts of attention between an object and a person and between person and person than both the control groups. They also spent less time overall looking at people, looked more briefly at people and for longer durations at objects, compared to the two control groups. In addition the infants with autism also showed less attention shifting overall than the two control groups. From this pattern of results, Swettenham et al. (1998) suggest that children with autism have a specific deficit in attending to social stimuli.

Swettenham et al. (1998) highlight age as a possible reason for the discrepancy between their study and the earlier study by Hermelin and O'Connor (1967). The children in the Hermelin and O'Connor study had a mean chronological age of 11 years and 4 months whereas those in the Swettenham study were aged 20 months. They suggest that an abnormality in orientation to social stimuli, present at an early age in autism may diminish during development.

Leekam, Lopez and Moore (2000) have also found difficulties in orienting which were specific to social cues. This study examined the ability of preschool children with autism (mean age 4 years 4 months) to orient to an adult's bid for attention and to follow the direction of a human or non-human cue. The results showed that children with autism were less responsive than developmentally delayed control children in orienting to attention bids and in following a human head turn cue, yet had no difficulty in shifting attention and were faster overall in orienting to non-social targets. Thus, from the results of these studies it is unclear whether

shifting attention poses a problem for the child with autism or whether they do not understand the significance of eye direction and other social signals as a guide to shift their attention to something of interest.

A number of studies have reported that eye gazes and faces in general lack significance for children with autism. For example, studies examining performance on visual perspective taking and gaze monitoring suggest that children with autism are able to monitor another's gaze but fail to do this spontaneously. Children with autism show a comparable performance to matched control groups on tasks in which a person turns their head or eyes towards an array of objects and they are asked to report what the person is looking at (visual perspective taking) (Baron-Cohen, 1989b, 1991; Dawson & Fernald, 1987; Hobson, 1984; Tan & Harris, 1991; Leekam, Baron-Cohen, Perrett, Milders & Brown, 1997). In contrast, children with autism fail to spontaneously monitor another's gaze on tasks that examine responses to a person's change of head or eye position (Scaife & Bruner, 1975; Leekam et al., 1997).

The latter observations have led Baron-Cohen (1995) to propose two mechanisms involved in joint attention behaviours. One mechanism (an eye direction detector or EDD) is responsible for the perception of another's gaze direction whereas the second mechanism (a shared attention mechanism or SAM) functions to identify if the subject and another person are both attending to the same thing. The EDD would seem to be intact in children with autism, while the SAM is in most cases impaired. Therefore, children with autism are able to detect whether eyes are looking at them, however were impaired in the use of eye direction to infer want and goal (Baron-Cohen et al., 1996).

Children with autism have also been found to rarely look at people's faces for information or reassurance. Sigman, Kasari, Kwon and Yirmiya (1992) conducted a

study where adults posed either fear or amusement at the arrival of a small robot. Few of the children with autism looked at either the parent or the experimenter and when they did look, their glances were much briefer than those of the mentally retarded or normal children who searched the faces of adults for reassurance. Similarly, Phillips, Baron-Cohen and Rutter (1992) showed that very young children with autism do not appear to use eye contact to disambiguate ambiguous actions. This study found that, on at least half of the trials, 100% of the typically developing children responded to the ambiguous action by instantly looking at the adult's eyes, showing that in conditions of uncertainty the first place young children look for information is the eyes. In contrast, only 11% of the children with autism seemed to use eye contact to resolve the uncertainty. Rutter and Schopler (1987) have also suggested that children with autism exhibit gaze avoidance and deviant patterns of reciprocal gaze. A similar conclusion was also reached by Volkmar and Mayes (1990) who assessed the spontaneous gaze behaviour in older children with autism and found that, compared to a developmentally delayed group, they looked less at staff with whom they were familiar. Other studies have shown that there may be a qualitative rather than a quantitative difference between eye gaze use in children with autism. Sigman, Mundy, Ungerer and Sherman (1986) found that children with autism looked at their caregivers as much as normal children although not at the same times as children without autism. Similarly, a study by Mirenda, Donnellan and Yoder (1983) has shown that children with autism tended to look at caregivers for longer periods during their own monologues than during a dialogue.

Clinical observations also indicate that children with autism fail to understand the significance of the eyes. They often fail to use eye contact to punctuate key parts of a conversation, for example when starting their utterance, to acknowledge praise

or interest, seek clarification, to read body language or to signify the end of the utterance (Attwood, 1998). Recent research studies (Baron-Cohen et al., 1995; Tantam, Holmes & Cordless, 1993) have also suggested there is a lack of eye gaze when the other person is talking. Personal accounts also confirm that eye gaze and looking at people's faces can be extremely difficult for the person with autism as described in the following quotation:

"Looking at people's faces, particularly into their eyes, is one of the hardest things for me to do. When I do look at people I have nearly always had to make a conscious effort to do so and then I can usually only do it for a second..... I cannot take in the whole face in one go (Jolliffe, Lansdown & Robinson, 1992, p15).

5.7 SUMMARY AND RATIONALE FOR SUBSEQUENT EXPERIMENTAL CHAPTERS

In summary, the bulk of evidence suggests that joint attention behaviours are deviant in children with autism. However it is unclear whether lack of joint attention behaviours stem from an inability to shift or modulate attention or whether social signals fail to be interpreted as cues to objects or situations of interest. On one hand studies have suggested that orienting attention is only problematic when it requires responding to social signals. Other studies have reported orienting deficits to both social and non-social cues.

However, most of these studies use accuracy as the dependent measure. It is also possible that children with autism might be slower to shift their attention. Leekam et al. (2000) used latency as the dependent measure and found that preschool children with autism were faster in orienting to targets. Joint attention or gaze following is often gauged by an overt head turn or eye shift by the child. This neglects the possibility that the visual orienting involved in the establishment of joint

attention could be the result of a covert process; that is, a shift of attention without the accompanying movement of the eyes or head. Moreover, it is unclear from the developmental studies on gaze following and joint attention whether orienting arises because of an automatic or relatively reflexive response or whether orienting is under voluntary control.

The results from the experiments reported in Chapter 3 would suggest that individuals with autism do not have difficulties in shifting attention covertly in either the voluntary or reflexive modes. Moreover, the pattern of results from the visual search tasks reported in Chapter 4 are not indicative of an attention shifting impairment in autism. It is possible therefore that the lack of joint attention behaviours seen in younger individuals with autism stems from difficulties in interpreting social signals as cues to objects or situations of interest. This could be the result of either a deficit in their covert attentional system, or to a lack of or delay in reflexively orienting to social cues.

The following three experimental chapters were designed to explore social attention in autism by adapting the paradigms used to study social orienting from the visual literature. The experiments reported in Chapter 6 examined whether individuals with autism orient their attention in an automatic fashion to social cues as seen in typically developing individuals and whether they could use these social cues as effectively as typically developing individuals.

The series of experiments in Chapter 6 also investigated two types of social cue, both eye gaze and head orientation. Previous research has indicated that eye gaze use is deviant in individuals with autism (see section 5.6), however, it was deemed important to consider whether a larger and more salient head direction cue would also pose difficulties. While the relative importance of eye gaze over head

orientation in the analysis of social attention among typically developing individuals is in dispute, the experiments reported in Chapter 7 were designed to investigate this in individuals with autism. While it is important to be attentive to the change in the direction of another's attention to facilitate the ebb and flow of a social interaction, it is equally important to be able to detect frontal eye gaze. The final experimental chapter reports on the results of a gaze perception task.

CHAPTER 6

Social Orienting

6.1 INTRODUCTION

The series of experiments reported in this chapter seeks to investigate social orienting in autism. The first three experiments were designed to investigate whether individuals with autism would show the typical orienting response to the direction of another's attention. The further three experiments explored whether individuals with autism were able to use social cues such as eye gaze and head direction information as effectively as normal controls when instructed to do so.

Experiment 1 adapted a traditional central cueing paradigm (Posner, 1980) where a digitised photograph of a face replaced the central arrow and the direction of seen gaze was manipulated. The pattern of results obtained by Driver et al. (1999) suggests that gaze perception triggers a reflexive visuospatial orienting response in normal adults. In Experiment 1 the eye gaze cues were completely uninformative of the likely target location. The same paradigm was used in Experiment 2 except the central stimulus was a photographed face where the direction of the whole head was manipulated. Thus the cueing stimuli in this experiment comprised both head and eye signals.

Experiment 3 involved the inversion of the stimuli used in Experiment 1. Face inversion severely disrupts face perception in normal subjects (Yin, 1969; Valentine, 1988; Rhodes, Brake & Atkinson, 1993; Farah, Wilson, Drain & Tanaka, 1998), although Langdell (1978) reported that children with autism do unexpectedly well in recognising upside-down faces. It was deemed important to investigate the performance of individuals

with autism on inverted stimuli and to ascertain whether a full face configuration is necessary to elicit a reflexive or relatively automatic orienting response.

In order to test subject's ability to use head and eye gaze cues to direct attention at will Experiments 4 to 6 selectively manipulate the likelihood that the cue accurately predicts the location of the target. Experiment 4 and 5 use the same stimuli as Experiments 1 and 2 respectively except the probability that the cue is predictive of target location is increased from 50% to 80% correct. Experiment 6 again used the same stimuli as Experiment 1 but the probability that the cue was predictive of target location was reduced to 20%. This manipulation therefore requires subjects to direct their attention away from the direction of seen gaze.

The results of Experiments 1-5 indicated that the group with autism displayed an optimal performance to targets following a SOA of 150ms. In the design of this series of experiments, cue duration was confounded with target onset at a SOA of 150ms. Therefore two additional experiments were carried out to investigate this possible confound. Experiments 7 and 8 were similar to Experiments 1 and 2 respectively except the cue duration varied with SOA.

6.2 METHOD – Study 3

Participants

Two groups of participants took part in this study: a group of seventeen high functioning adults with ASD (10 males, 2 females with Asperger's Syndrome and 3 males, 2 females with high-functioning Autism) and a comparison group of seventeen developmentally normal adults (14 males and 3 females). Recruitment, diagnosis and ability testing were performed in the same way as previous experiments. Ten subjects from both groups had participated in the visual search tasks reported in Chapter 4 approximately six months

previously. Participants' characteristics are shown in Table 6.1. Independent sample t-tests revealed that the chronological ages, VIQ, PIQ and IQ of the two groups were not significantly different ([t(32)=1.07, p=0.29], [t(32)=0.15, p=0.88],[t(32)=-0.06, p=0.95] and [t(32)=0.06, p=0.96]) respectively. All participants had normal or corrected to normal vision.

Table 6.1. Participant characteristics

Group	N		AGE(y:m)	VIQ	PIQ	Overall IQ
Autism	17	Mean	20.10	88.88	92.12	89.47
		SD	3.3	13.13	16.85	14.33
		Range	16.6-26.6	73-112	72-123	72-118
Normal	17	Mean	19.9	88.29	92.41	89.24
		SD	2.5	9.48	12.17	10.10
		Range	16.6-25.9	75-110	75-120	75-114

Stimuli and Apparatus

The visual attention task was presented on a 15-inch monitor controlled by a Texas Instruments Travel mate 6030 computer with one millisecond timing for control of stimulus display, recording of reaction time and error data. The visual display for this task consisted of a 4 cm square central box marked by a fixation point (+) in the middle and flanked by two 4cm square boxes on the left and right set at 6.5 degree of visual angle. The peripheral target was a small white square presented against a dark display background in one of the boxes on either side of fixation. A scanned photograph of a female face served as the central cue in Experiment 1. This was 4 degrees in height and width. The left and right gaze cues were produced by a mirror reflection of the eye region to ensure symmetry

between stimuli. The differing eye regions were pasted onto the same scanned face photograph using Adobe Photoshop software. The central cue in Experiment 2 was a scanned photograph of a female face whose head direction was manipulated. The head direction cues were produced using a mirror reflection of the opposite facing cue. The central cues for Experiment 3 involved rotating the images used in Experiment 1 through 180 degrees. Experiment 4 and 6 used the same stimuli as Experiment 1 where the probability of the eye direction being predictive of target location was manipulated. In Experiment 4 the probability of the eye direction being predictive of target location was 80% correct. In Experiment 6 this probability was reduced to 20% correct. Experiment 5 used the same stimuli as experiment 2 where the probability of the head direction being predictive of target location was 80%. An example of each of the 6 experiments is shown in Figures 6.1 to 6.6.

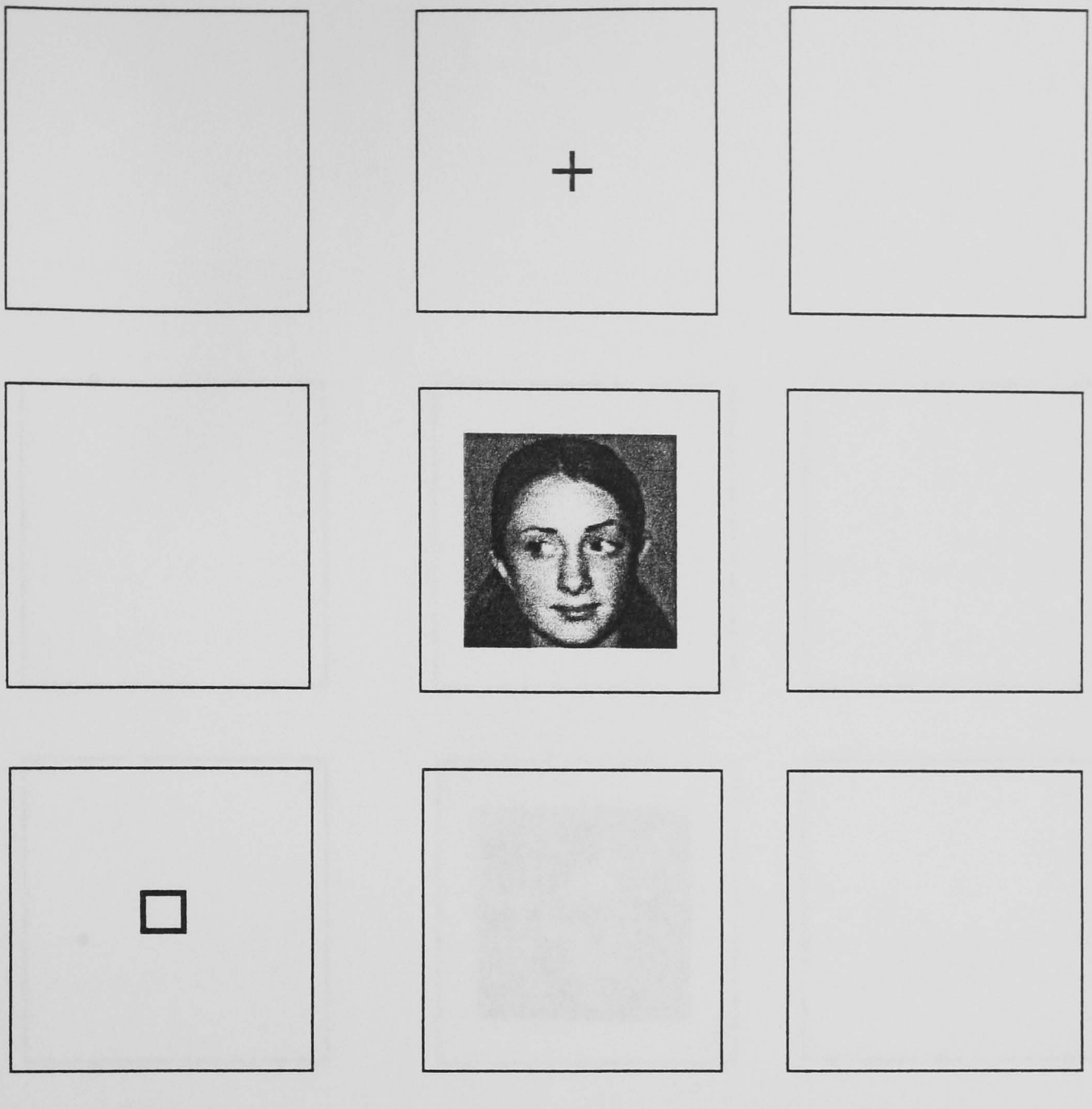


Figure 6.1 An example of a congruent trial in Experiment 1

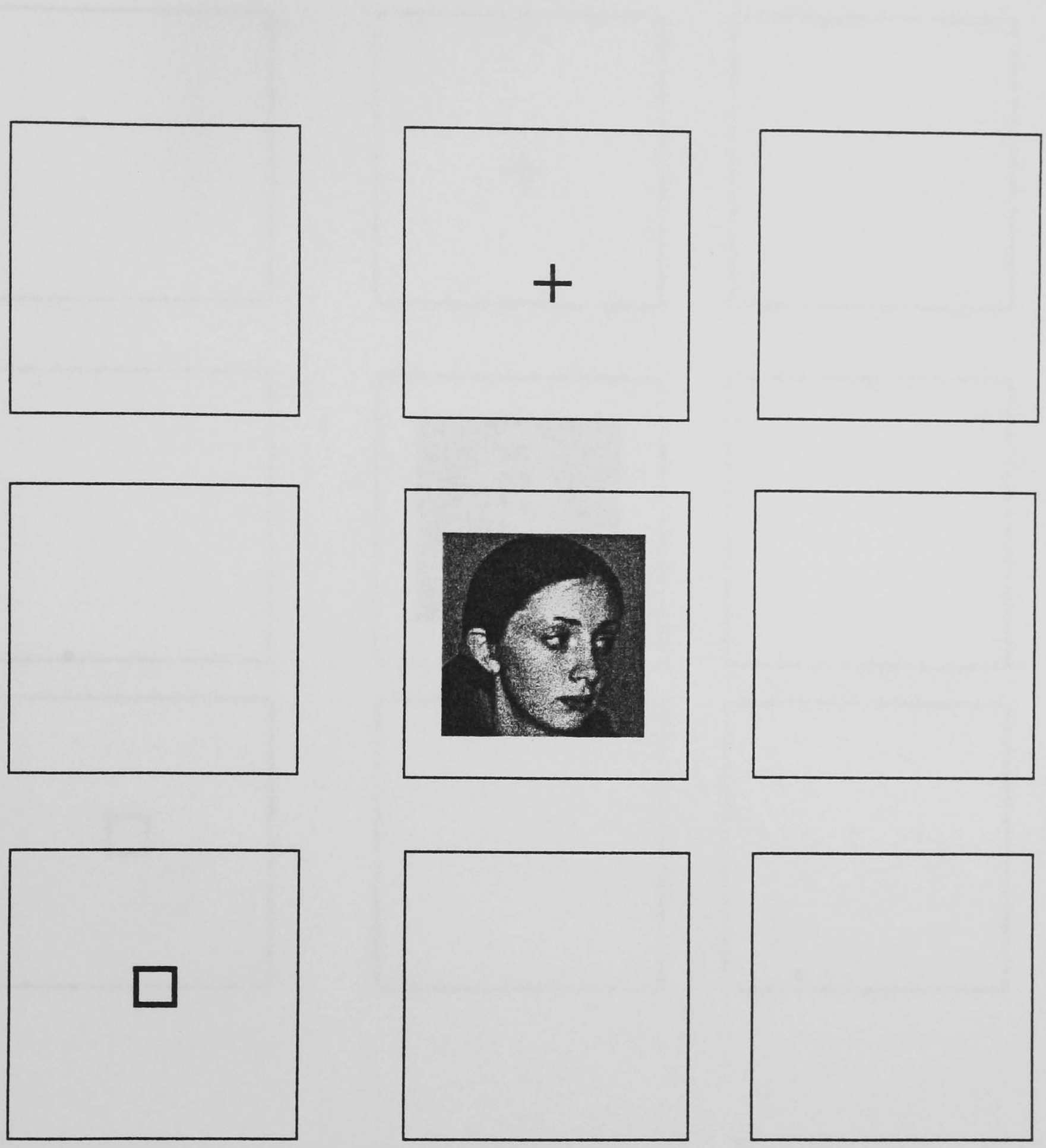


Figure 6.2 An example of an incongruent trial in Experiment 2.

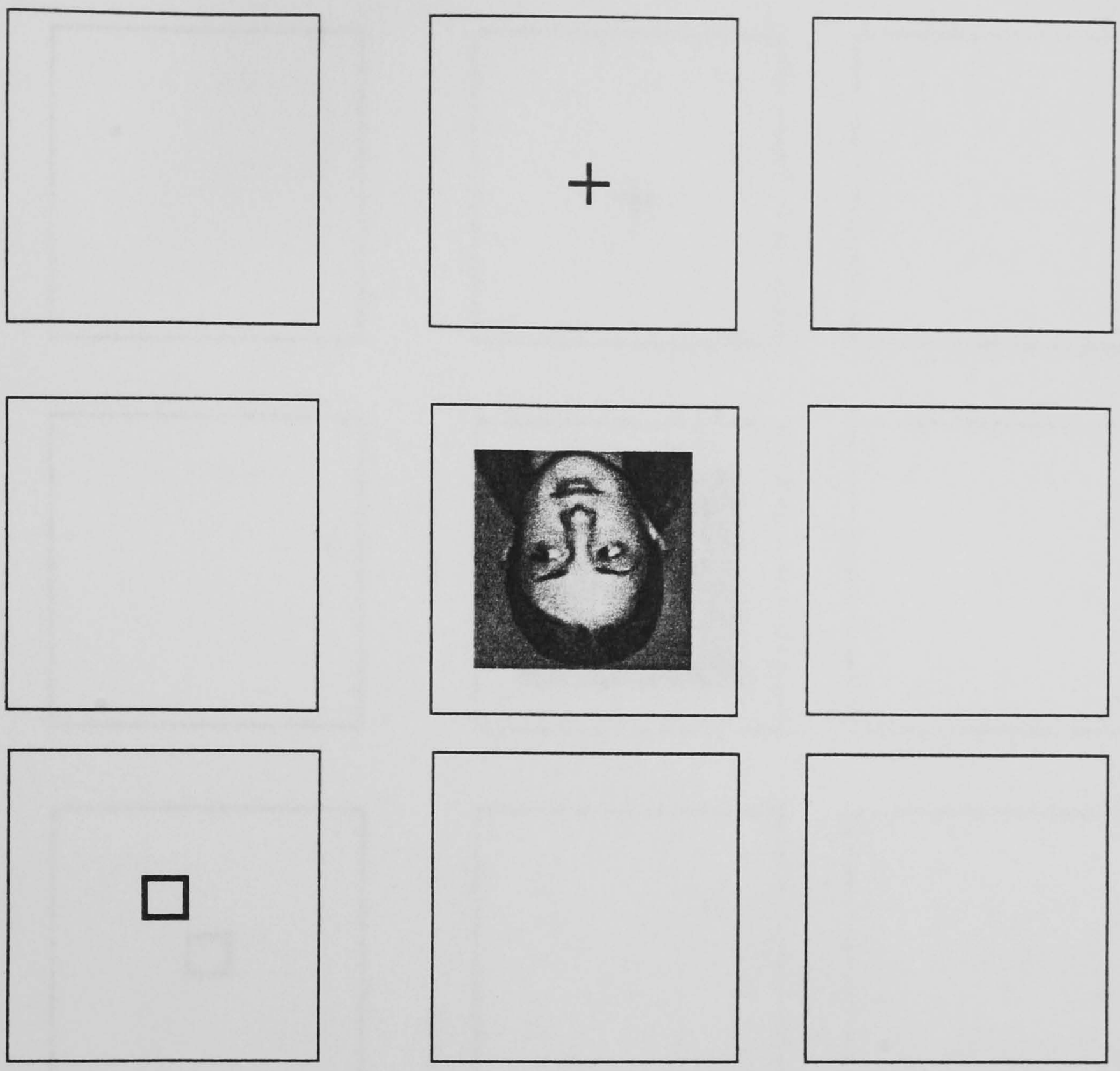


Figure 6.3. An example of a congruent trial in Experiment 3.

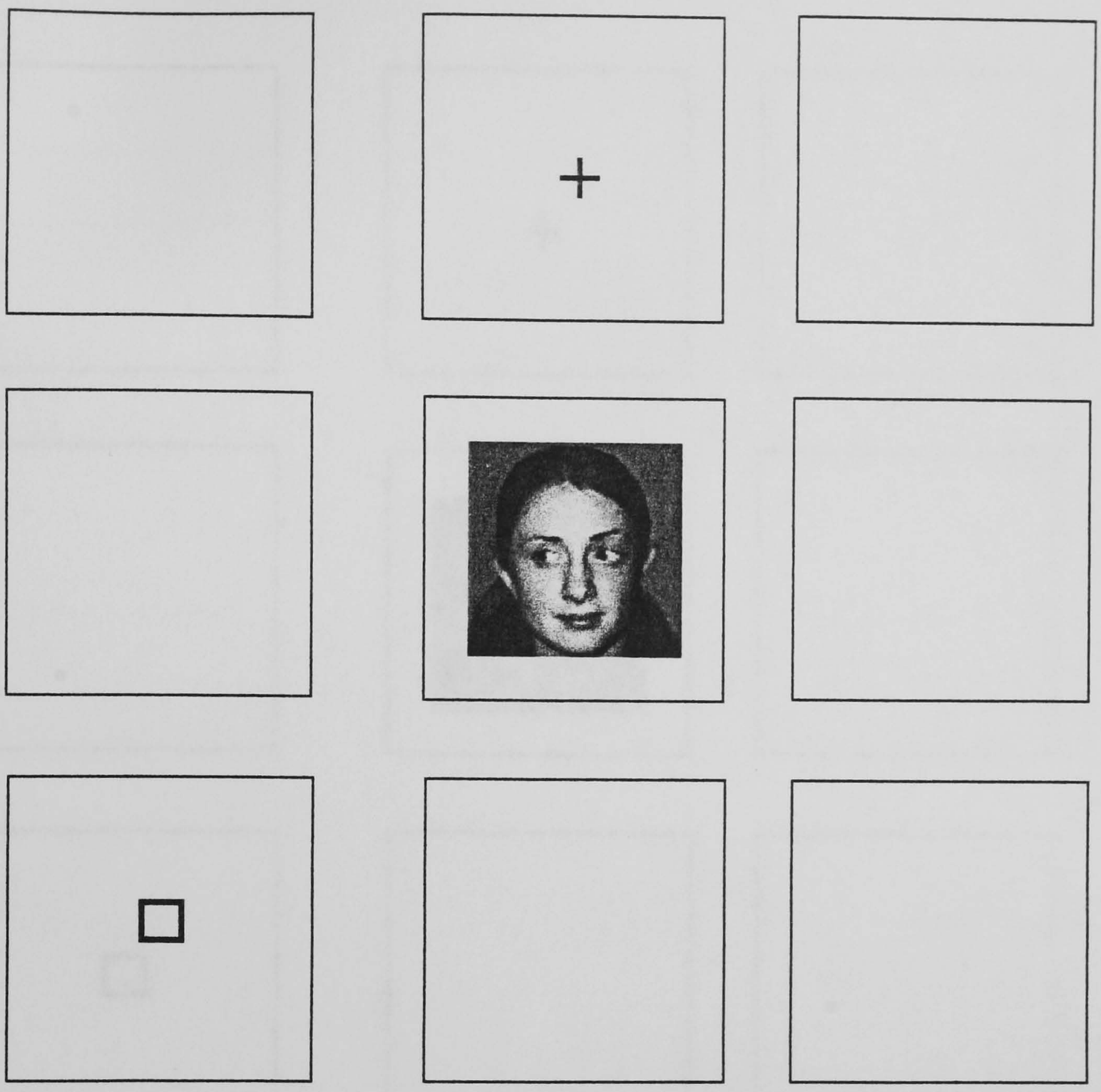


Figure 6.4. An example of an expected trial in Experiment 4.

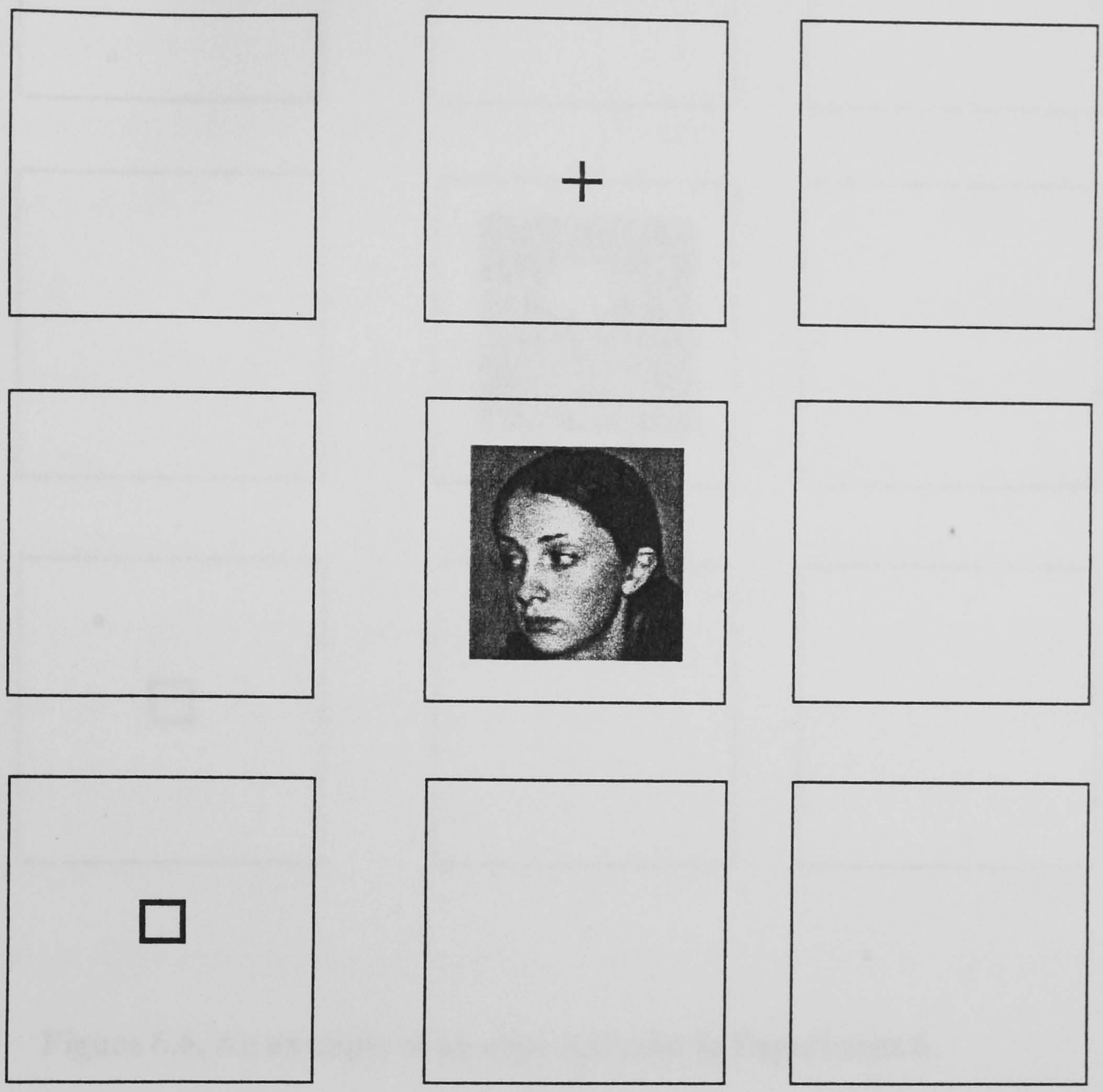


Figure 6.5. An example of an expected trial in Experiment 5

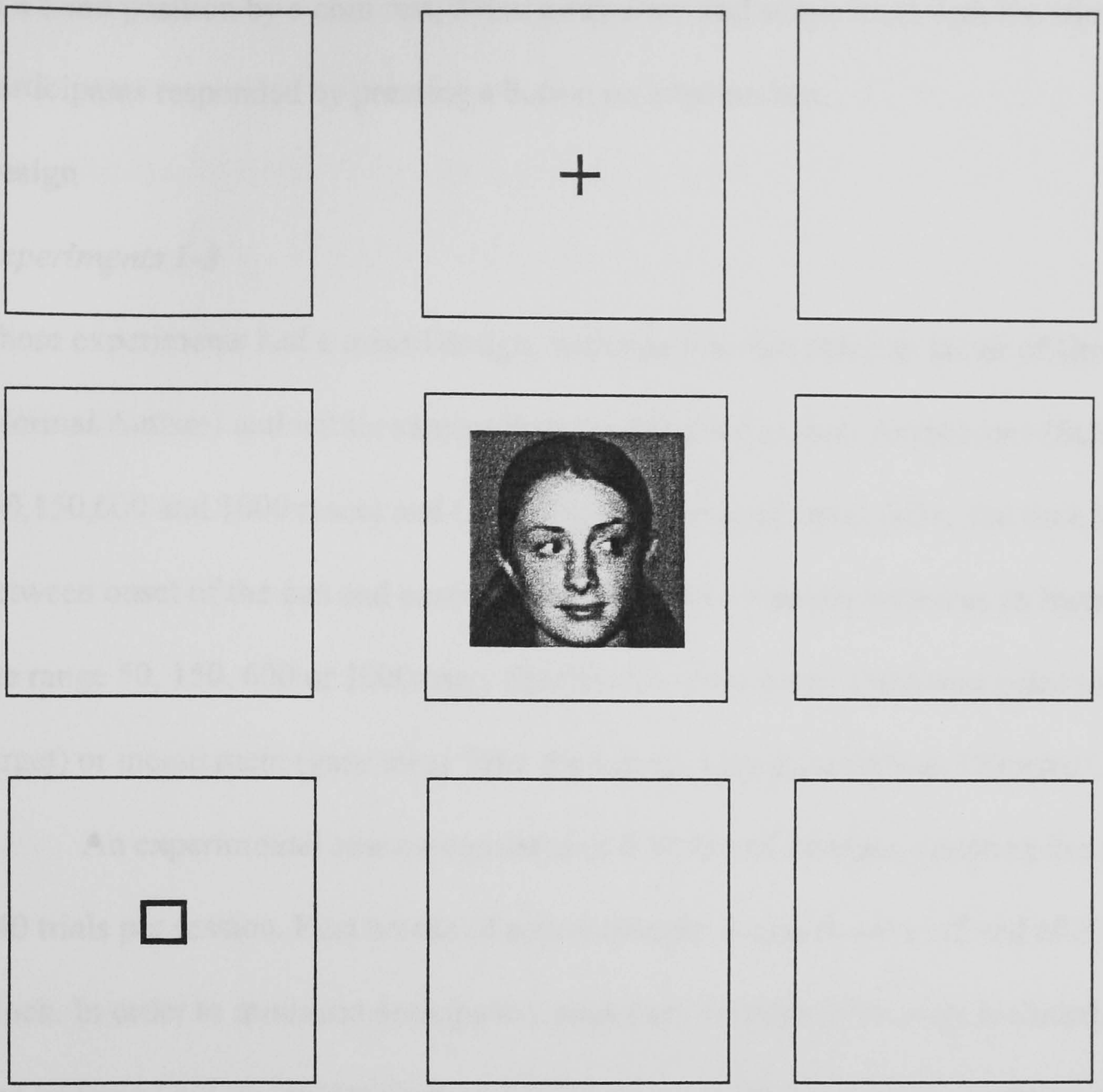


Figure 6.6. An example of an expected trial in Experiment 6

The participant was seated in front of the computer screen, while the head was held in a fixed position by a chin rest, 57cm away from and at eye level with the stimuli. Participants responded by pressing a button on a button box.

Design

Experiments 1-3

These experiments had a mixed design, with one between subjects factor of Group (Normal/Autism) and within subject factors of Stimulus Onset Asynchrony (SOA) (50,150,600 and 1000 msec) and Cue (Congruent/Incongruent). SOA, the time interval between onset of the cue and onset of the target was randomly varied as an interval from the range 50, 150, 600 or 1000msec. Spatial cues were either congruent (gaze towards the target) or incongruent (gaze away from the target). Cue duration was 150msec.

An experimental session consisted of 6 blocks of 40 trials, resulting in a total of 240 trials per session. Rest breaks of approximately 1 minute were offered after every block. In order to minimise anticipatory responses 48 catch trials were included, where a cue appeared but no target followed. Of the remaining trials, 96 had congruent cues and 96 had incongruent cues. Target location was equally divided between right and left visual fields and SOAs were equally and randomly distributed between blocks. Targets remained on the screen until the participant responded or for a maximum of 1500msec. Trials were deemed misses if a response was not made within 1200 msec and were included in the error data analyses. Following a response a 500ms inter-trial interval was imposed. In catch trials, the display remained on the screen for 1500msec and was then followed by a 500msec inter-trial interval. For each participant, RTs less than 100msec were scored as anticipatory and included in the error data analyses.

Experiments 4-6

These experiments had a mixed design, with one between subjects factor of Group (Normal/Autism) and within subject factors of SOA (50,150, 600 and 1000ms) and Cue (Expected/Unexpected). In Experiments 4 and 5 participants were told to direct their attention towards the direction in which the image was looking as 80% of the time the image predicted where the target was likely to appear. In Experiment 6 participants were told try and direct their attention away from the direction in which the eyes were looking as only 20% of the time was the eye direction predictive of target location. Spatial cues were either expected or unexpected. An experimental session consisted of 6 blocks of 48 trials, resulting in a total of 288 trials. Of these 192 were expected trials, 48 were unexpected trials and 48 were catch trials. All other aspects of these experiments were as described in Experiments 1-3.

Experiments 7-8

Experiment 7 and 8 were identical to Experiments 1 and 2 respectively except the cue duration coincided with variations in SOA.

Procedure

Experiments 1-3

Testing of individuals took place in an interview room at the participant's institution. Ability testing was carried on a separate occasion prior to the experiment. Each participant was told that they were helping to find out how quickly people could detect a target. They were told to keep their eyes on the fixation cross in the centre of the screen. Then following a short delay a series of pictures would appear at fixation. It was repeatedly emphasised that the central face cues were entirely irrelevant to the target detection task

and they were to ignore these, as the direction of the gaze gave no information about the likely location of the target. Participants were told that on some trials no target would appear and they were to refrain from responding on those trials. The chin rest was introduced and explained that this was to ensure that their eyes remained level with the display. Participants were encouraged to keep their eyes on the fixation cross and told not to move either their eyes or their head. Participants were asked to press the button on the button box with their dominant hand as quickly as possible when the target square appeared. Participants received 16 practice trials before the start of the experiment. The order in which participants received experiment 1, 2 and 3 was counterbalanced.

Experiments 4-6

The procedure for this set of experiments was similar to Experiments 1-3 except for a slight change in the experimental instructions. In Experiment 4 and 5 subjects were now told to pay attention to the central pictures as 80% of the time the direction of "looking" was predictive of where the target was likely to appear. In Experiment 6 they were told to try and attend in the opposite direction of where the central stimulus was looking, as she was correct only 20% of the time. The order in which participants received experiment 4, 5 and 6 was counterbalanced.

Experiments 7-8

The procedure for these two experiments was identical to that of Experiment 1 and 2 respectively. All participants received Experiments 1-3 before completing Experiments 4-6 approximately 6 weeks later. Subsequently 16 participants from each group were available for re-testing and Experiments 7 and 8 were conducted after a period of approximately 4 months. Figure 6.7 provides a summary of the 8 experiments reported in this chapter.

Experiment	Cue duration	Stimuli	Probability of cue being predictive of target	Instructions with regard to the central cue
1	150ms		50%	Ignore
2	150ms		50%	Ignore
3	150ms		50%	Ignore
4	150ms		80%	Attend to direction
5	150ms		80%	Attend to direction
6	150ms		20%	Opposite direction
7	Varied with SOA		50%	Ignore
8	Varied with SOA		50%	Ignore

Figure 6.7. A summary of the methods used in all eight experiments

6.3 RESULTS

Experiment 1 (Eye gaze cue)

Reaction times

The median reaction for each target delay and condition were calculated for each subject. Figure 6.8 shows the mean RTs in Experiment 1 for both the group with autism and the comparison group. This data was compared using ANOVA with a between subject factor of Group (Autism/Normal) and within subject factors of Cue (Congruent/Incongruent) and SOA (50,150, 600 and 1000msec).

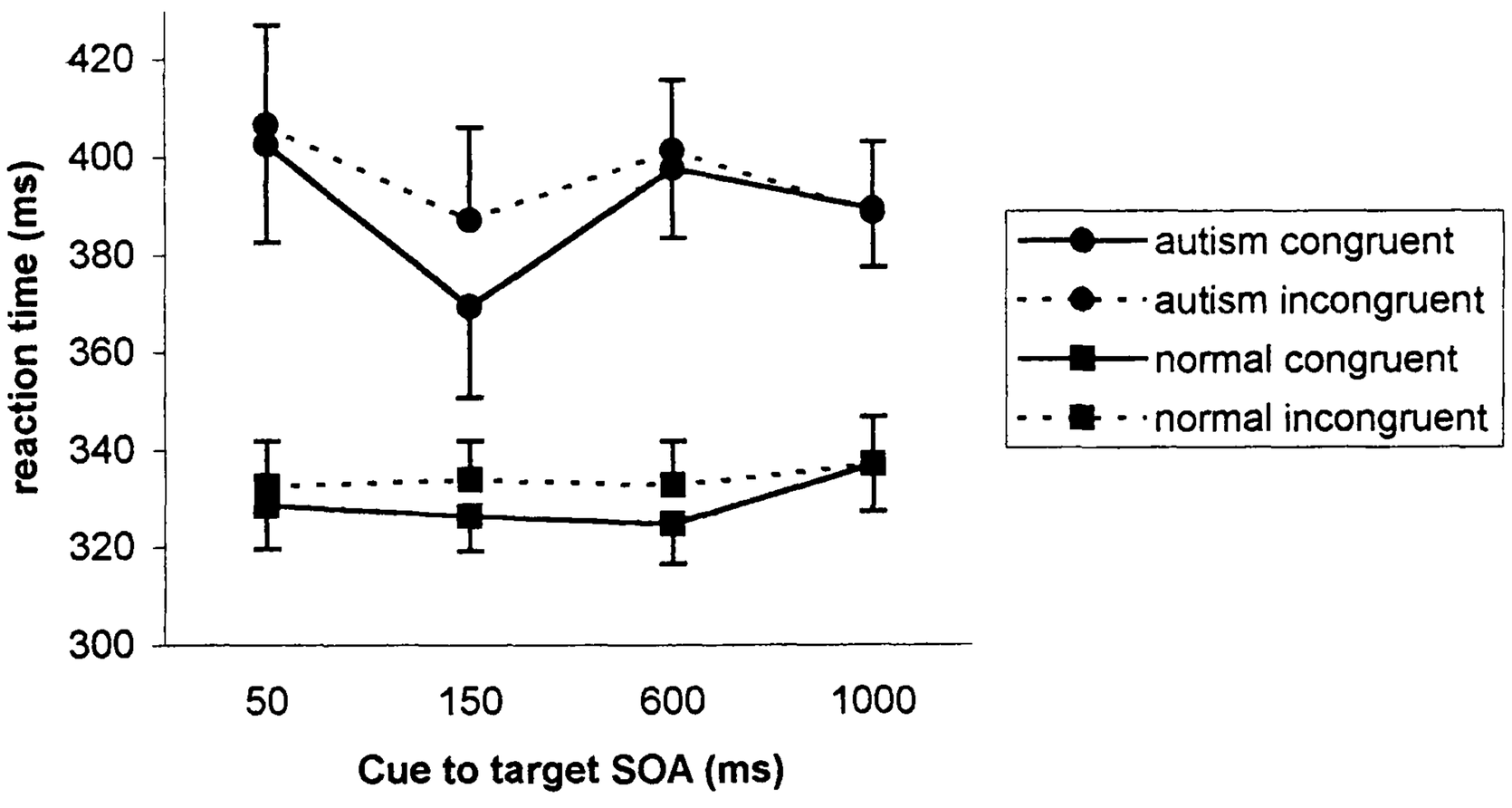


Figure 6.8. Mean reaction times in Experiment 1 to targets at varying intervals following an eye gaze directional cue (50% probability).

There was a significant difference between the two groups in overall reaction time [F (1,32)=11.62, p=0.002]. There was a significant main effect of Cue [F (1,32)=8.94, p<0.005] and a significant main effect of SOA [F (3,96)=3.24, p<0.03]. This analysis confirmed that RT was facilitated on congruently cued trials relative to incongruently cued trials and that response latencies varied with SOA. Two interaction terms were also significant. These were a SOA by Group interaction [F (3,96)=4.21, p<0.008] and a Cue by

SOA interaction [F (3,96)=2.80,p<0.04]. All other interaction terms were not significant (Cue by Group [F (1,32)<1, ns] and Cue by SOA by Group [F (3,96)<1, ns].

Simple effects tests revealed that the SOA by Group interaction was attributable to a significant effect of SOA for the group with autism [F (3,96)=6.75, p<0.01] but not for the comparison group [F (3,96)<1, ns] and a significant effect of Group at an SOA of 50ms [F (1,32)=4.23, p<0.05] but not at SOAs of 150ms[F (1,32)=1.79, p>0.05], 600ms [F (1,32)=3.88, p>0.05] or 1000ms [F (1,32)=2.11, p>0.05]. This pattern of results suggests that the subjects with autism are especially slow at an SOA of 50ms but show a marked amelioration of this deficit at 150ms which is not maintained at the longer SOA periods. In contrast, the profile shown by the comparison group is remarkably consistent across changes in SOA.

Simple effects tests revealed that the Cue by SOA interaction was attributable to a significant effect of SOA at congruent trials [F (3,96)=3.14, p<0.05] but not incongruent trials [F (3,96)<1, ns] and a significant effect of Cue at an SOA of 150ms [F (1,32)= 11.69, p<0.01] but not at SOAs of 50ms [F (1,32)=1.14,p>0.05], 600ms [F (1,32)=2.52, p>0.05] or 1000ms [F (1,32)=1.94, p>0.05].

Validity Effects

To examine the 'validity' effects of cueing the mean of the RT scores of the invalid trials were subtracted from that for the valid trials at each SOA. Figure 6.9 shows the validity effects from both groups. These were compared using ANOVA with a between subject factor of Group (Normal/Autism) and a within subject factor of SOA (50,150,600 and 1000msec). This analysis revealed a significant main effect of SOA [F (3,96)=2.80, p<0.04]. There was no significant effect of Group [F (1,32<1, ns] or SOA by Group interaction [F (3,96)<1, ns].

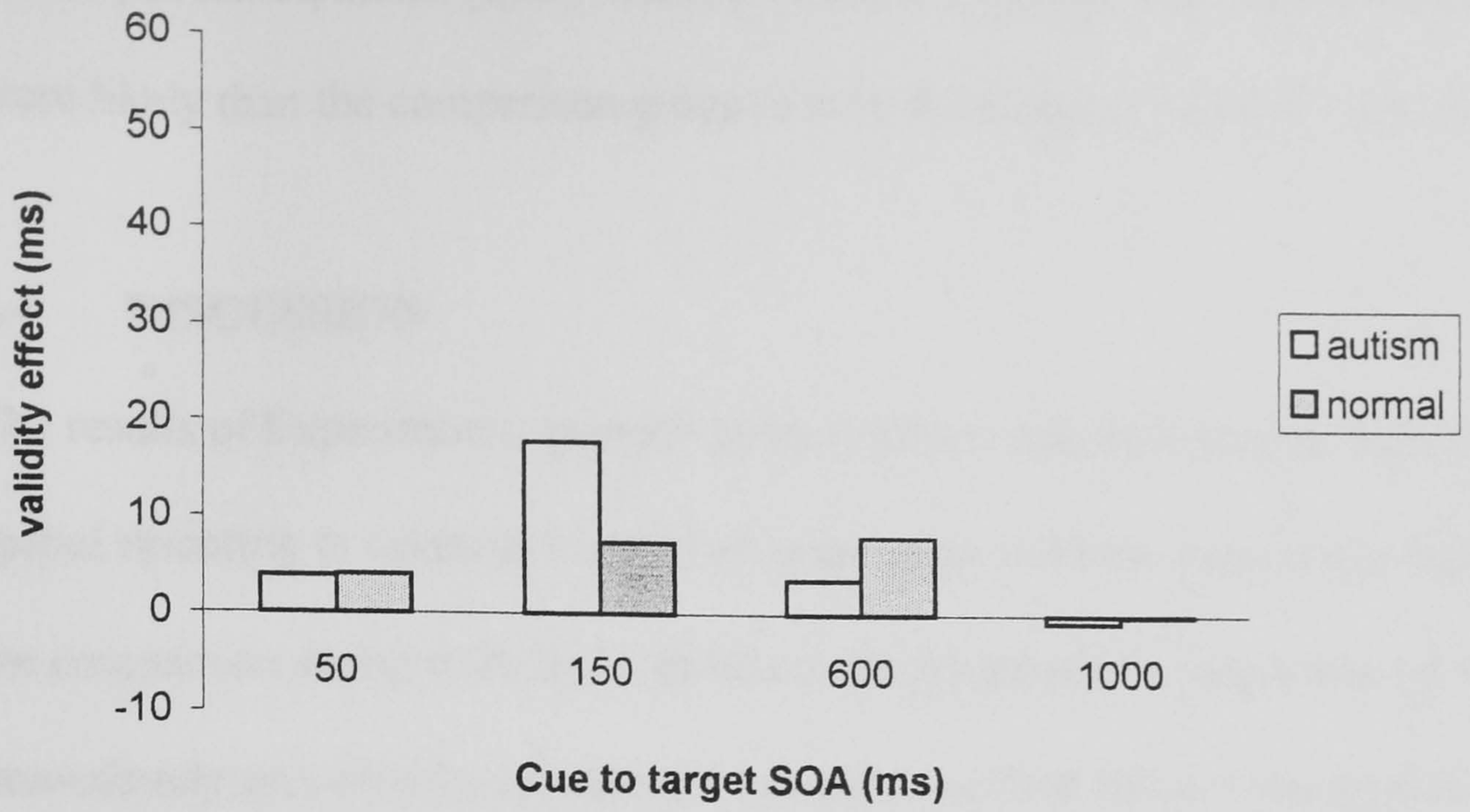


Figure 6.9. Validity effects in Experiment 1 n (difference between congruent and incongruent trials) following an eye gaze directional cue (probability 50%).

Error data

The mean (SD) number of errors was calculated for each group. Table 6.2 shows the error data from Experiment 1.

Table 6.2. Mean (SD) number of errors from both groups in Experiment 1.

	Normal	**Autism**
Catch (Response made)	0.35 (0.61)	0.76 (1.03)
Anticipations (RT < 100ms)	1.06 (1.20)	1.29 (1.31)
Miss (RT > 1200 ms)	0.35 (0.61)	1.41 (1.94)

Independent t-tests revealed no significant differences on either catch trials [t(32)=1.42, p<0.17] or anticipations [t(32)= 0.55, p<0.59]. The group with autism were significantly more likely than the comparison group to miss the target [t(32)=2.15, p<0.039].

6.4 DISCUSSION

The results of Experiment 1 provide some evidence that both groups showed reflexive spatial orienting to centrally located eye gaze cues. Both the individuals with autism and the comparison group were faster to detect the presence of a target when it was immediately preceded by a congruent eye gaze cue than when it was preceded by an incongruent eye gaze cue. While central cues are normally thought to engage an endogenous orienting mechanism (Müller & Rabbitt, 1989), the observations reported in this study are consistent with an exogenous or stimulus driven orienting mechanism based on three criteria. Firstly, this facilitatory effect occurred despite the fact that these centrally located eye gaze cues were not predictive of the location of the target and secondly the participants were instructed to ignore the cue. Finally, this cueing effect was rapid, appearing at 150ms after the onset of the eye gaze cue, and was short lived (absent for the longer SOAs). These results are concordant with those reported by Driver et al. (1999) who adopted a similar cueing methodology using normal adults. Participants in the Driver et al. (1999) study were faster to discriminate peripheral target letters on the side the computerized face gazed towards, even though the seen gaze did not predict target side and despite participants being asked to ignore the face.

The fact that the group with autism were overall slower in detecting the target and were more likely to miss the target perhaps reflects a general arousal problem (Hutt et al., 1964) or perhaps an autism-specific deficit in social-motivational factors. This finding of longer target detection latencies has been found in other studies with these subjects (Neely

et al., submitted). Moreover, it should be noted that general slowing in reaction times on Posner type spatial cueing tasks has been observed in patients with frontal-lobe lesions (Petersen et al., 1989).

6.5 RESULTS

Experiment 2 (Head directional cue)

Reaction times

These data were treated in the same way as Experiment 1. Figure 6.10 shows the mean RTs for both the group with autism and the comparison group. This analysis confirmed that the group with autism were overall slower in responding [$F(1,32) = 10.59$, $p<0.003$]. There was also a main effect of SOA [$F(3,96)=4.20$, $p<0.008$] and an SOA by Group interaction [$F(3,96)=4.15$, $p<0.008$]. All other main effects and interaction terms were not significant (Cue [$F(1,32)=2.53$, $p>0.05$], Cue by Group [$F(1,32<1$, ns], Cue by SOA [$F(3,96)<1$, ns] and Cue by SOA by Group [$F(3,96)=1.36$, $p>0.05$)].

Simple effect tests revealed that the SOA by Group interaction was attributable to an effect of SOA for the group with autism [$F(3,96)= 7.66$, $p<0.01$] but not the comparison group [$F(3,96)<1$, ns]. There was no effect of Group at each of the SOAs (50 [$F(1,32)=3.94$, $p>0.05$], 150 [$F(1,32)=1.56$, $p>0.05$], 600 [$F(1,32)=3.57$, $p>0.05$] and 1000 [$F(1,32)=1.92$, $p>0.05$]).

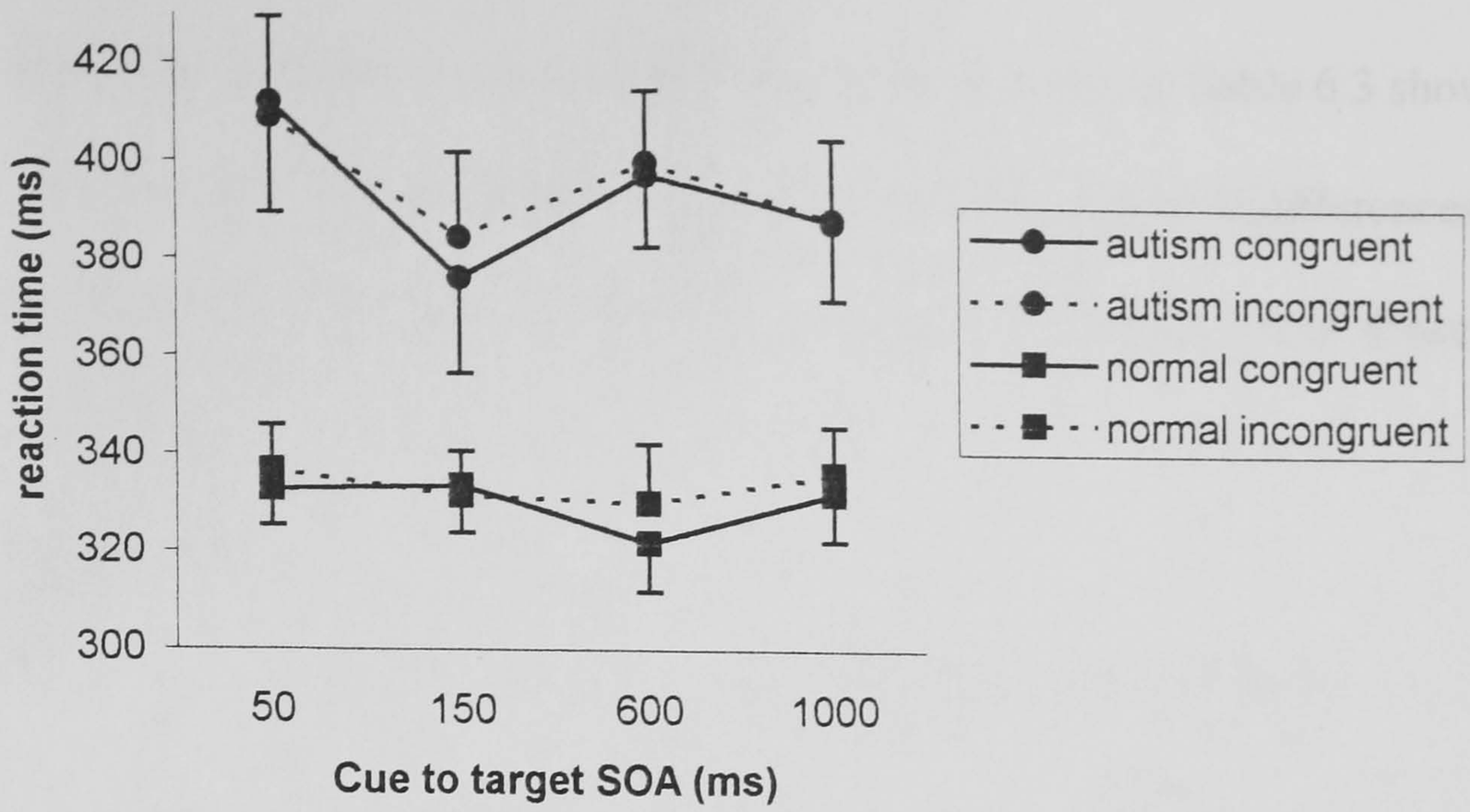


Figure 6.10. Mean reaction times in Experiment 2 to targets at varying intervals following the head cue (50% probability).

Validity effects

These data were calculated and compared as above. Figure 6.11 shows the validity effects from both groups. No significant results were found. (SOA [F (3,96)=0.34, p=0.80], SOA by Group [F (3,96)=1.36, p=0.26] and Group [F (1,32)=0.15, p=0.70]).

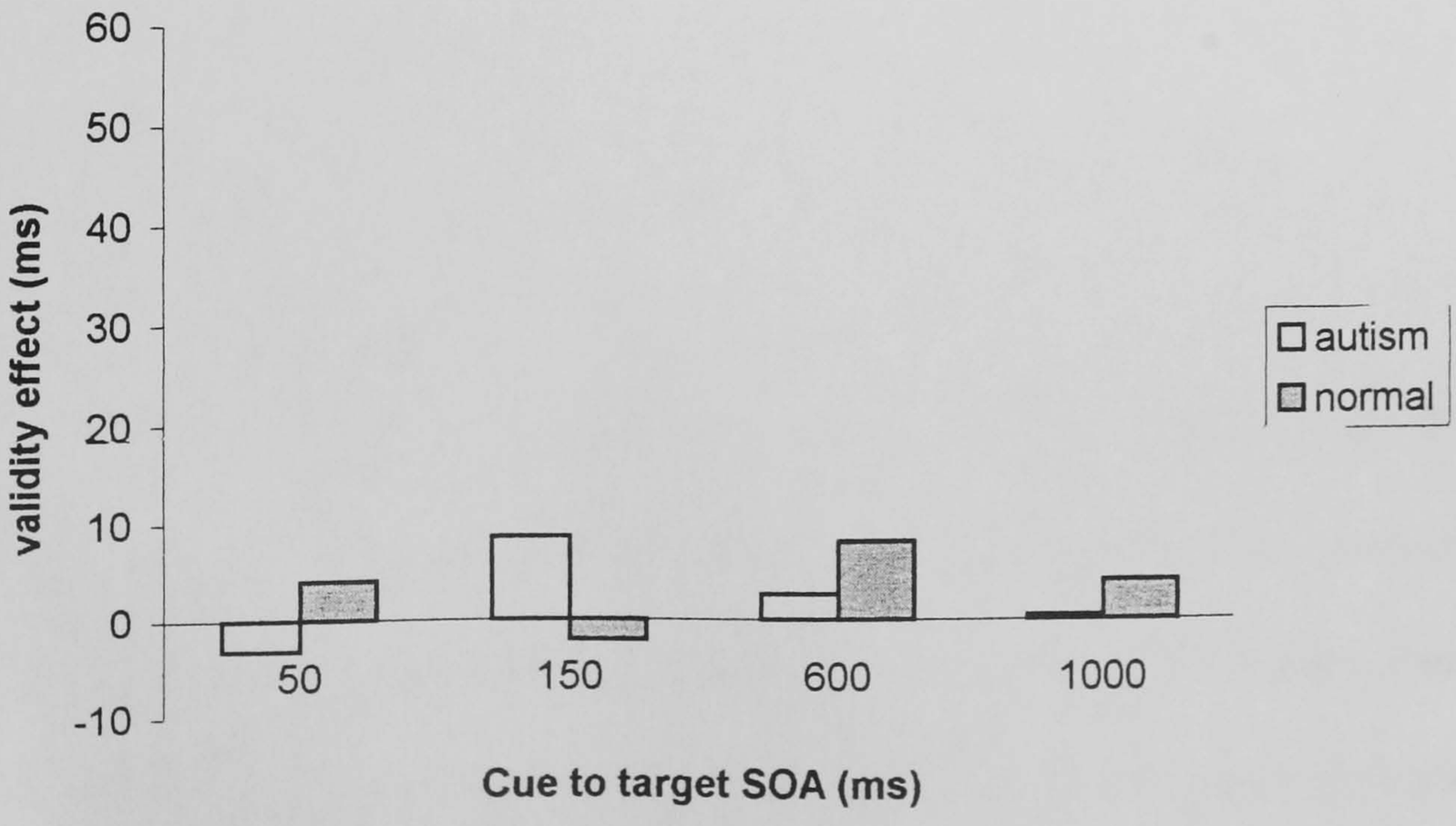


Figure 6.11. Validity effects in Experiment 2 (difference between congruent and incongruent trials) following a profile head cue (probability 50%).

Error Data

The mean (SD) number of errors was calculated for each group. Table 6.3 shows the error data from Experiment 2. Independent t-tests revealed no significant differences on either catch trials [$t(32)=1.497$, $p<0.14$], false alarms [$t(32)= 1.596$, $p<0.12$] or misses [$t(32)=1.084$,$p<0.287$].

Table 6.3. Mean (SD) number of errors for each group in Experiment 2.

	Normal	**Autism**
Catch (Response made)	0.29 (0.77)	0.82 (1.24)
False Alarm (RT < 100ms)	0.65 (0.86)	1.24 (1.25)
Miss (RT > 1200 ms)	0.41 (0.62)	1.00 (2.15)

6.6 DISCUSSION

The results of Experiment 2 did not provide evidence of reflexive orienting in response to a head cue in either group. Although in this experiment both the head and the eyes were oriented towards one of the possible target locations, subjects from both groups were able to ignore these cues as they were instructed to do. These results are not concordant with those of Langton and Bruce (1999) using normal adults. In the Langton and Bruce (1999) study participants were required to detect a target in one of four possible locations, left, right, above or below the cue. The results revealed that uninformative and to be ignored

head cues produced faster target detection latencies at cued relative to uncued locations, but only when the cues appeared 100ms before the onset of the target. At the longer SOA of 1000ms, no effects of cue were found. While the slight differences in task design may reconcile the discrepancy between the two studies it is unclear why subjects in Experiment 1 were unable to ignore the eye gaze direction whereas they were able to ignore both the eye and head direction in Experiment 2.

Hietanen (1999) has reported similar findings to those recorded in this paper and has proposed a possible reason for this discrepancy. Hietanen (1999) examined the contribution of gaze direction and head orientation on attentional shifts and found that a laterally averted view of a head with a straight gaze did not elicit fast automatic shifts in visual attention whereas a frontal face with an averted gaze did. Hietanen (1999) suggests that psychologically, a head directed and looking away may be interpreted as a situation that is totally unrelated to ones-self, perhaps depicting a person engaged in his/her own thoughts. In contrast, a frontal view of a face with a gaze turned away is much more powerful, signalling that something has attracted his/her attention so much that he/she is looking at it. A laterally averted gaze indicates that the person is actively looking at something, thus pulling our attention to the same spatial location. In this way, it is possible that a frontal view of a face is interpreted as a more powerful social signal.

6.7 RESULTS

Experiment 3 (Inverted eye gaze cue)

Reaction times

These data were also calculated and compared as above. Figure 6.12 shows the mean RTs for both the autism and the comparison group. There was a main effect of Group [$F(1,32)= 15.61$, $p<0.001$] suggesting a significant difference in overall reaction times

between the two groups. This analysis also revealed a significant main effect of SOA [F (3,96)=7.23, p<0.001], a Cue by Group [F (1,32)=7.21, p<0.01] and a SOA by Group [F (3,96)=4.05, p<0.009] interaction. All other main effects and interaction terms were not significant (Cue [F (1,32)=0.25, p=0.62], Cue by SOA [F (3,96)=0.40, p=0.76] and Cue by SOA by Group [F (3,96)=0.33, p=0.80].

Simple effect tests revealed that the Cue by Group interaction was attributable to a significant effect of Cue for the group with autism [F (1,32)=5.07, p<0.01] but not the normal control group [F (1,32)=2.39, p>0.05] and a more significant effect of Group for the congruent trials [F (1,32)=9.12, p<0.01] than the incongruent trials [F (1,32)=6.60, p<0.05].

Simple effect tests show that the SOA by Group interaction was attributable to a significant effect of SOA for the group with autism [F (3,96)= 8.77, p<0.01] but not for the normal control group [F (3,96)=2.50, p>0.05] and a significant effect of Group for SOAs of 50ms [F (1,32)=4.96, p<0.05] and 600ms [F (1,32)=5.54, p<0.05] but not at SOAs of 150ms [F (1,32)=3.09,p>0.05] or 1000ms[F (1,32)=2.44, p>0.05].

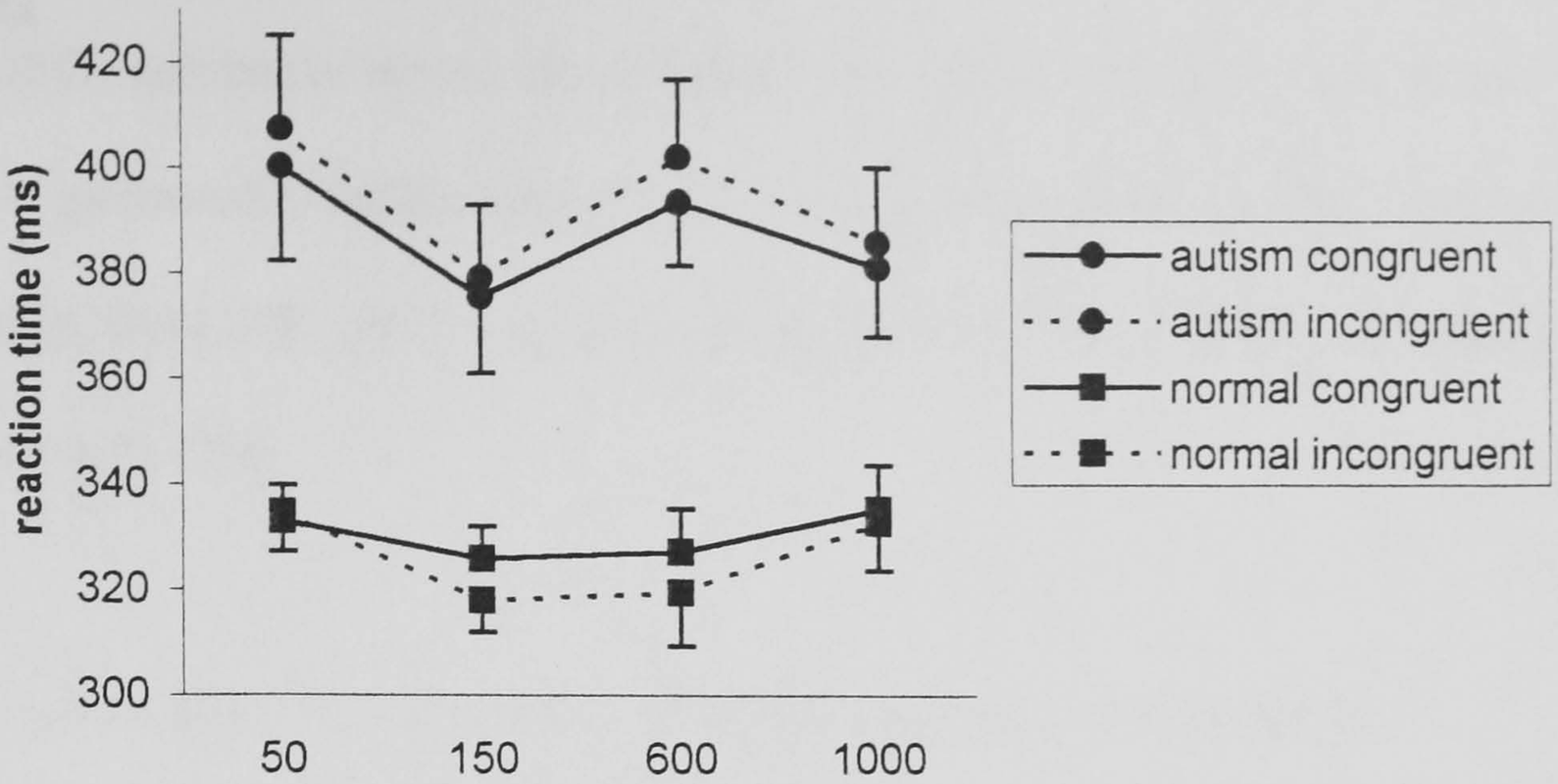


Figure 6.12. Mean reaction times in Experiment 3 to targets at varying intervals following an inverted eye gaze directional cue (50% probability).

Validity effects

Figure 6.13 shows the scores from each group on this measure. This analysis revealed a significant difference between the two groups [F (1,32)=7.21, p=0.01]. There was no main effect of SOA [F (3,96<1, ns] nor a SOA by Group interaction [F (3,96<1, ns].

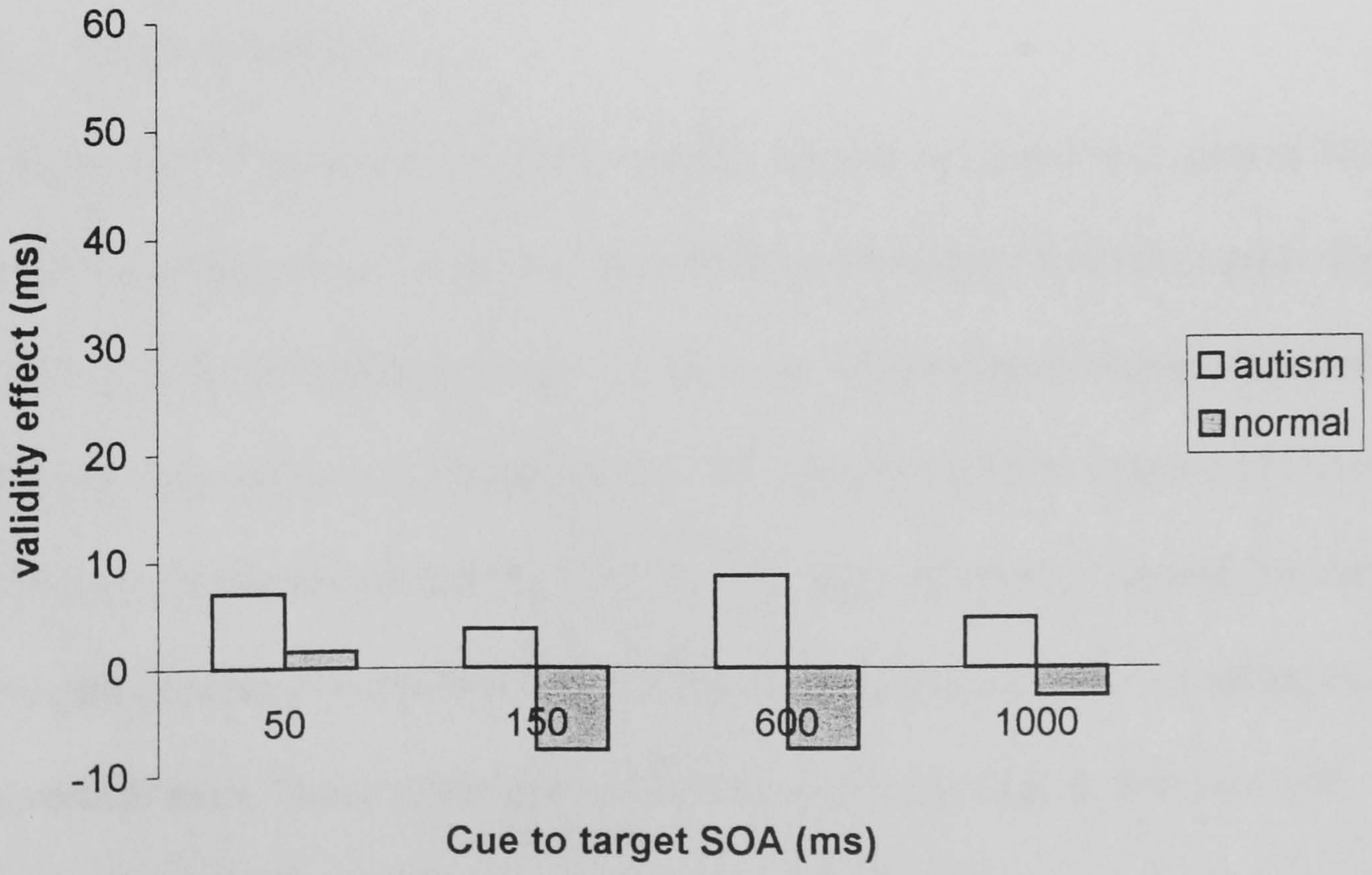


Figure 6.13. Validity effects (difference between congruent and incongruent trials) in Experiment 3 following an inverted eye gaze directional cue (50% probability).

Error Data

The mean (SD) number of errors was calculated for each group. Table 6.4 shows the error data from Experiment 3. Independent t-tests revealed no significant differences on either catch trials [t(32)=1.573, p=0.126], false alarms [t(32)= 0.736, p=0.467] or misses [t(32)=1.012,p=0.319].

Table 6.4. Mean (SD) number of errors from both groups in Experiment 3.

	Normal	**Autism**
Catch (Response made)	0.18 (0.39)	0.65 (1.17)
False Alarm (RT < 100ms)	0.71 (0.99)	1.06 (1.71)
Miss (RT > 1200 ms)	0.29 (0.59)	0.71 (1.57)

6.8 DISCUSSION

In Experiment 3, the cueing stimuli used in Experiment 1 were each rotated about 180 degrees to produce a set of inverted frontal faces with laterally averted gaze. The results showed that for the comparison group, inversion of the stimuli disrupted the reflexive orienting response seen in Experiment 1. This is in accordance with results from Langton and Bruce (1999) who found that inversion of the facial stimuli reduced the cueing effect to targets appearing on the horizontal axis and abolished the effect of cueing to targets on the vertical axis. These results are also in line with numerous studies that have demonstrated that inversion severely disrupts various aspects of face processing (Yin, 1969; Valentine & Bruce, 1986: Bruce & Langton, 1994). In addition Vecera and Johnson

(1995) demonstrated that sensitivity to gaze direction in schematic faces was reduced when the eyes were in the context of an inverted or scrambled face compared to an upright face.

However, the group with autism produced a different pattern of results, indicating that inversion of the stimuli did not disrupt the processing of the eye gaze direction. This may be related to a pioneering study of face recognition in adolescents and young adults with autism by Langdell (1978), where two peculiarities were reported. While the individuals with autism were as proficient as control subjects matched on chronological age and performance IQ in their ability to identify their peers, they did so by relying on the lower parts of the face (i.e. the mouth region), rather than the upper parts of the face (i.e. the eye region) which is a more normative strategy (McKelvie, 1976). In addition they also failed to show the typical decrement in performance when asked to identify inverted faces. Similar results were obtained by Hobson, Ouston and Lee (1988) who found that the individuals with autism in their study, when asked to identify upside down faces, performed better than control subjects matched for verbal mental age.

This enigma has been interpreted as evidence of a lack of central coherence (Happé, 1994) as, although the processing of faces involves both featural (part) and configural (whole) processing (Tanaka & Farah, 1993), it appears that configural processing is interrupted by the inversion of faces. Alternatively, while neuropsychological evidence suggests a dissociation between neural mechanisms for face and object perception (Yin, 1970; Farah et al., 1998; Farah, 1996), recent investigations using functional magnetic resonance imaging (fMRI) (Haxby et al., 1999) have indicated that failure of face perception systems with inverted faces leads to the recruitment of processing resources in object perception systems. Therefore it is possible that individuals with autism do not have specialised systems for the perception of faces, relying instead on

an intact object recognition system for their analysis. Indeed, there is some preliminary data that appears to point in this direction (Schultz et al., 2000), showing abnormal ventral temporal cortical activity among individuals with autism and Asperger's Syndrome during a face discrimination task. It was suggested by these authors that the individuals with autism demonstrated a pattern of brain activity during face discrimination that was consistent with feature-based strategies that are more typical of non-face object perception.

6.9 RESULTS

Experiment 4 (Predictive eye gaze cue)

Reaction times

The median reaction time for each target delay and condition were calculated for each participant. Figure 6.14 shows the mean RTs for both the group with autism and the comparison group. The mean RT scores were compared using ANOVA with a between subject factor of Group (Autism/Normal) and within subject factors of Cue (Expected/Unexpected) and SOA (50,150,600 and 1000msec). There were no significant differences between the two groups in overall reaction time [$F(1,32)=2.83$, $p>0.05$]. There was a main effect of Cue [$F(1,32)=20.46$, $p<0.001$] and a main effect of SOA [$F(3,96)=7.84$, $p<0.001$] indicating faster reaction times for expected targets at increasing cue to target delays. There was also a significant SOA by Group interaction [$F(3,96)=4.26$, $p<0.007$] and a Cue by SOA by Group interaction [$F3,96)=4.36$, $p<0.006$]. All other interaction terms were not significant (Cue by Group [$F(1,32)=2.06$, $p>0.05$], Cue by SOA [$F(3,96)=0.94$, $p>0.05$].

Simple effect tests revealed that the SOA by Group interaction was attributable to a more significant effect of SOA for the group with autism [$F(3,96)=7.34$, $p<0.01$] than the comparison group [$F(3,96)=4.75$, $p<0.05$].

The three-way interaction of Cue by SOA by Group was attributable to a significant Cue by SOA interaction for the normal group [F (3,96)=3.79, $p<0.05$] but not the group with autism [F (3,96)=1.51, $p>0.05$].

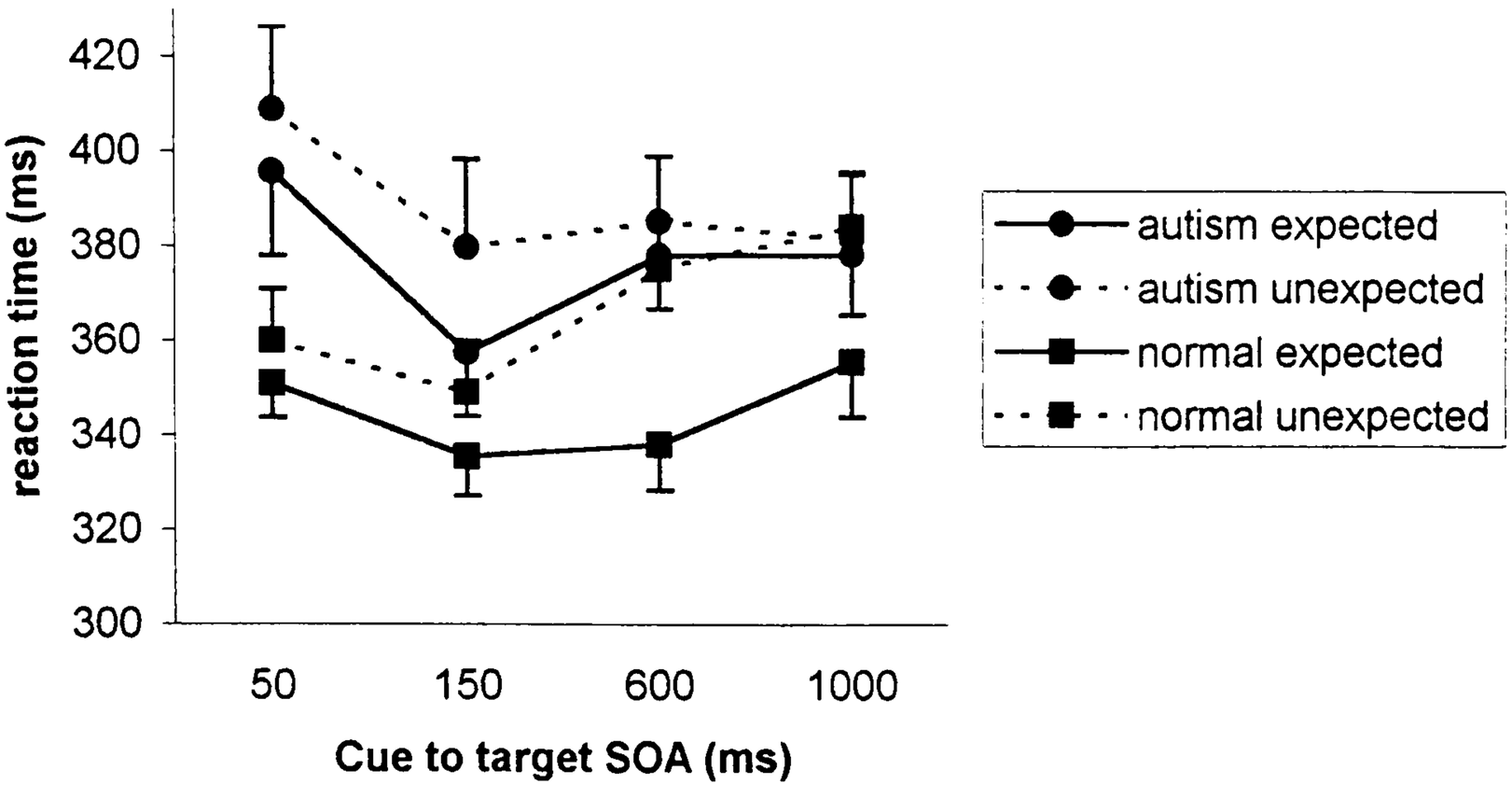


Figure 6.14. Mean reaction times in Experiment 4 to targets at varying intervals following an eye gaze directional cue (probability 80% correct).

Validity effects

To examine the 'validity' effect of cueing the mean of the RT scores of the unexpected trials were subtracted from the expected trials at each SOA. The scores from both groups are shown in Figure 6.15. These were compared using ANOVA with a between subject factor of Group (Normal/Autism) and a within subject factor of SOA (50,150, 600 and 1000msec). There was no main effect of Group [F (1,32)=2.06, $p>0.05$] or SOA [F (3,96)=0.94, $p>0.05$]. However there was a significant SOA by Group interaction [F (3,96)=4.36, $p<0.006$]. Simple effect tests revealed that this interaction was attributable to a significant effect of SOA for the comparison group [F (3,96)=3.79, $p<0.05$] but not the group with autism [F (3,96)=1.51,$p>0.05$]. Independent sample t-tests revealed that the difference between groups was apparent at SOAs of 600 [t (32)=2.73, $p<0.01$] and

1000msec [t (32)=2.01, p<0.05] but not at SOAs of 50 [t (32)=-0.42,p=0.68] or 150msec [t (32)=-0.84, p=0.41].

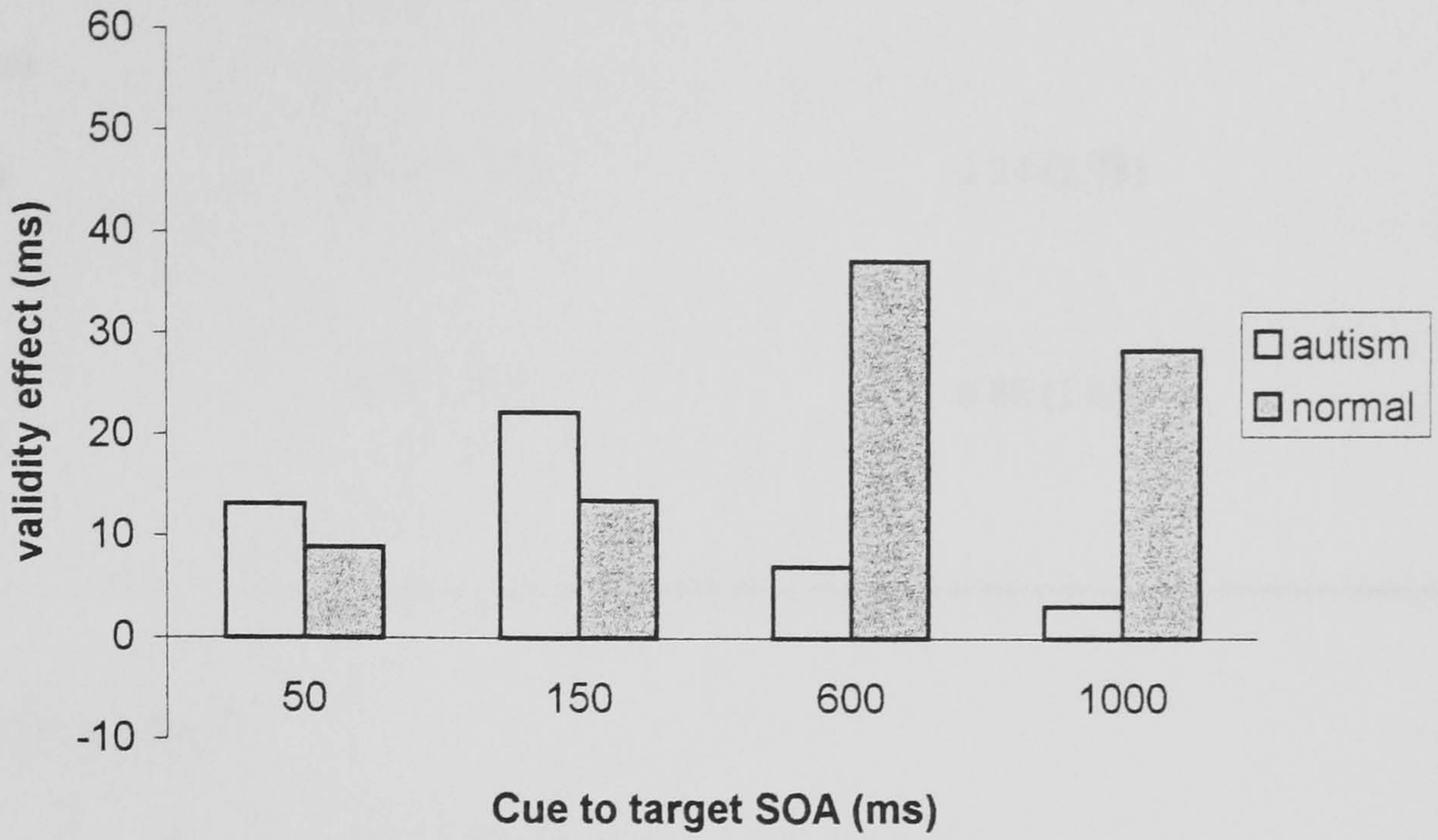


Figure 6.15. Validity effects (difference between expected and unexpected trials) in Experiment 4 following an eye gaze directional cue (80% probability).

Error Data

The mean (SD) number of errors was calculated for each group. Table 6.5 shows the error data from each group in Experiment 4. Independent t-tests revealed no significant differences on either catch trials [t(32)=0.385, p<0.703], false alarms [t(32)=-0.296, p<0.769] or misses [t(32)=0.739,p<0.465].

Table 6. 5. Mean (SD) number of errors in each group in Experiment 4.

	Normal	**Autism**
Catch (Response made)	1.12 (1.27)	1.29 (1.40)
False Alarm (RT < 100ms)	2.47 (2.53)	2.24 (2.08)
Miss (RT > 1200 ms)	0.53 (1.07)	0.88 (1.65)

6.10 DISCUSSION

The stimuli for Experiment 4 were identical to that in Experiment 1 except that the probability of the central gaze cue being predictive of subsequent target location was increased to 80% and participants were encouraged to pay attention to the cue. It was predicted that this manipulation would produce little difference in results from Experiment 1 at the shorter SOAs of 50 and 150ms if we assume that these were the consequence of a purely stimulus-driven or exogenous orienting process. However with increasing cue to target delays participants should have enough time to be able to interpret the cue and affect a strategic or endogenous shift of attention contingent on the direction of the cue. The results from the comparison group supported this prediction and show that the comparison subjects were able to supplement their relatively automatic tendency to align their attention with the direction of seen gaze with their voluntary allocation of attention with longer cue to target delays of 600 and 1000ms. However, it seems that the individuals with autism were not as efficient in voluntarily using the eye gaze cue to direct their attention as evidenced by the differences between groups in terms of validity effects at the longer cue to target delays of 600 and 1000ms. These results may be concordant with studies

reporting difficulties with eye gaze use among younger individuals with autism (Mirenda et al., 1983; Sigman et al., 1986; Volkmar & Hayes, 1990; Rutter & Schopler, 1987; Phillips, Baron-Cohen & Rutter, 1992) and also clinical, anecdotal and personal evidence among older individuals (Attwood, 1998; Jolliffe et al., 1992).

The overall group differences in reaction time were no longer significant in this experiment. This may be due to the effect of greater practice or a more general feeling at ease with the experimental procedure among the group with autism. Indeed, this amelioration in overall reaction time with subsequent similar experiments was reported in previous experimental chapters.

6.11 RESULTS

Experiment 5 (Predictive head cue)

Reaction times

Figure 6.16 shows the mean RT for both groups. The data were compared as above. This analysis revealed no significant differences between the two groups in overall reaction times [$F(1,32)=1.29$, $p>0.05$]. There were significant main effects of Cue [$F(1,32)=12.08$, $p<0.001$] and SOA [$F(3,96)=8.62$, $p<0.001$] indicating faster reaction times for expected targets at increasing cue to target delays. There was also a significant Cue by SOA interaction [$F(3,96)=3.31$, $p<0.02$] and a SOA by Group interaction [$F(3,96)=3.01$, $p<0.03$]. All other interaction terms were not significant (Cue by Group [$F(1,32)<1$, ns], Cue by SOA by Group [$F(3,96)<1$, ns].

Simple effect tests revealed that the source of the Cue by SOA interaction was attributable to a significant effect of Cue at a SOA of 600ms [$F(1,32)= 7.81$, $p<0.01$] but not at SOAs of 50 [$F(1,32)<1$, ns], 150 [$F(1,32)=1.94$, $p>0.05$] or 1000msec [F

(1,32)=3.73,p>0.05] and a more significant effect of SOA at expected trials [F (3,96)=5.37, p<0.01] than at unexpected trials [F (3,96)=4.98, p<0.01].

Simple effect tests revealed that the SOA by Group interaction was attributable to a significant effect of SOA for the autistic group [F (3,96)=9.87, p<0.01] but not the comparison group [F (3,96)=1.76,p>0.05].

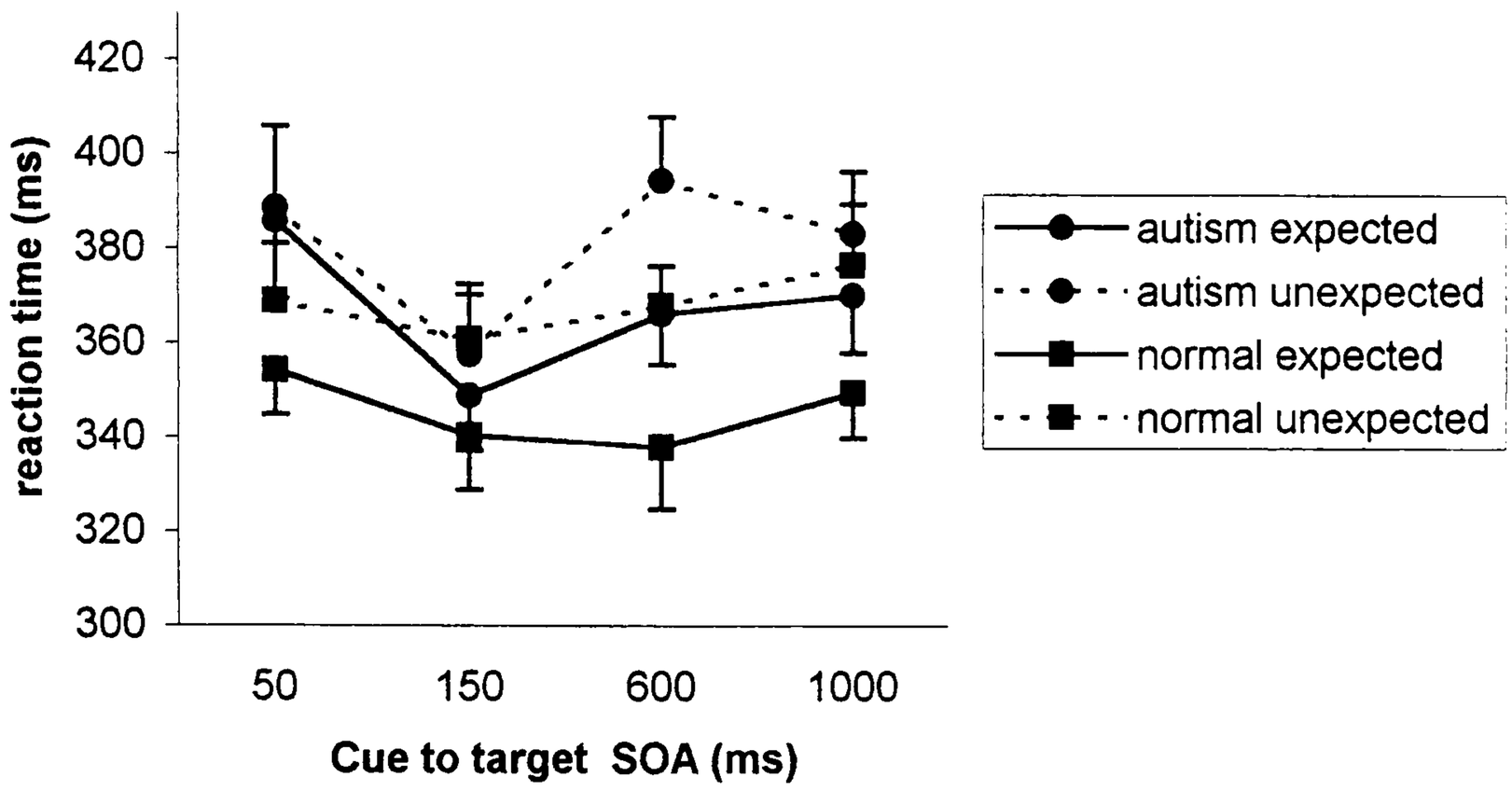


Figure 6.16. Mean reaction times in Experiment 5 to targets at varying intervals following the head cue (probability 80% correct).

Validity effects

This analysis revealed a significant main effect of SOA [F (3, 96)=3.31,p=0.02]. The scores from both groups are shown in Figure 6.17. There was no main effect of Group [F (1,32)<1, ns] nor a SOA by Group interaction [F (3,96)<1, ns].

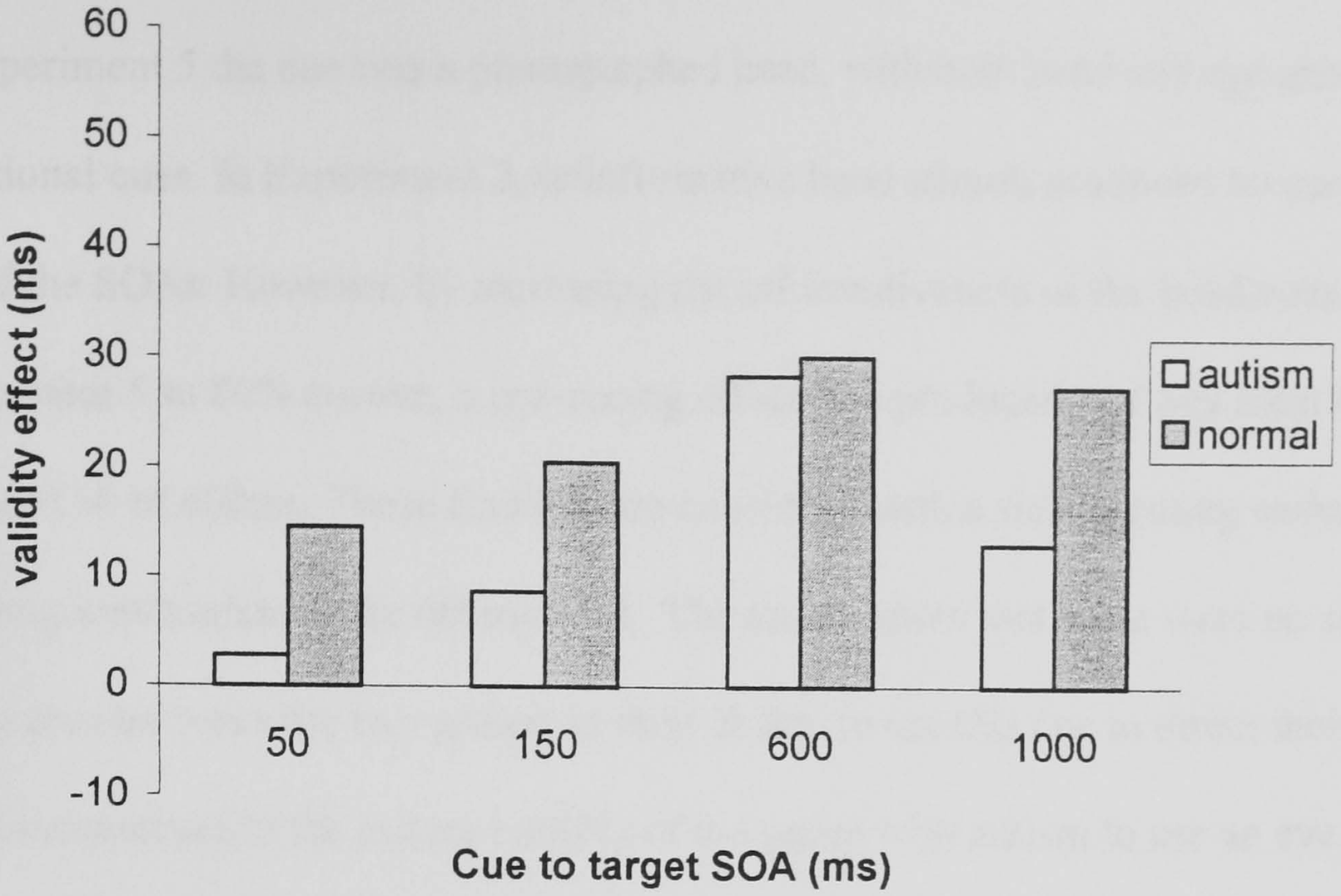


Figure 6.17. Validity effects in Experiment 5 (difference between expected and unexpected trials) following a profile head directional cue (80% probability).

Error Data

The mean (SD) number of errors was calculated for each group. Table 6.6 shows the error data from Experiment 5. Independent t-tests revealed no significant differences on either catch trials [t(32)=-0.941, p<0.354], false alarms [t(32)=0.699, p<0.490] or misses [t(32)=-0.672,p<0.506].

Table 6.6. Mean (SD) number of errors from both groups in Experiment 5.

	Normal	**Autism**
Catch (Response made)	1.18 (1.33)	0.71 (1.57)
False Alarm (RT < 100ms)	1.71 (1.72)	2.47 (4.17)
Miss (RT > 1200 ms)	0.94 (1.56)	0.59 (1.50)

6.12 DISCUSSION

In Experiment 5 the cue was a photographed head, with both head and eye gaze as directional cues. In Experiment 2, uninformative head stimuli produced no cueing effect at any of the SOAs. However, by increasing the informativeness of the head cues in Experiment 5 to 80% correct, a pre-cueing effect was produced and was most evident at a longer SOA of 600ms. These findings are consistent with a slower acting endogenous orienting mechanism at the 600ms SOA. The results show that there were no significant differences between the two groups in their ability to use this cue to direct their attention. This is in contrast to the reduced ability of the group with autism to use an eye gaze cue as effectively as control subjects in Experiment 4. This could be an indication that the individuals with autism have particular difficulty with the eyes. Head direction and gaze direction were always perfectly correlated in Experiment 5. Possibly the subjects with autism were able to use the larger and more salient head direction as the cue. Alternatively, as mentioned previously, the individuals with autism may have a tendency to shift their attention to the lower regions of the face (Langdell, 1978) thus using the nose as a directional cue.

6.13 RESULTS

Experiment 6 (Invalidly predictive eye gaze cue)

Reaction times

These data were treated as above. Figure 6.18 shows the mean RT for both groups. This analysis revealed no significant differences between the two groups in overall reaction time [$F(1,32)<1$, ns]. There were main effects of Cue [$F(1,32)=9.45$, $p<0.004$] and SOA [$F(3,96)=3.35$, $p<0.02$]. There was also a significant Cue by SOA interaction [$F(3,96)=7.20$, $p<0.001$]. The Cue by Group [$F(1,32)=2.02$, $p>0.05$] and the SOA by Group

[F (3,96)<1, ns] interactions were not significant, however the Cue by SOA by Group interaction approached significance [F (3,96)=2.40, p=0.07].

Simple effect tests revealed that the Cue by SOA interaction was attributable to a significant effect of Cue at SOAs of 600 [F (1,32)=6.71), p<0.05] and 1000msec [F (1,32)=7.81, p<0.01] but not at SOAs of 50 [F (1,32)<1, ns] or 150msec [F (1,32)<1, ns] and a significant effect of SOA at expected trials [F (3,96)=4.70, p<0.01] but not at unexpected trials [F (3,96)=1.78, ns].

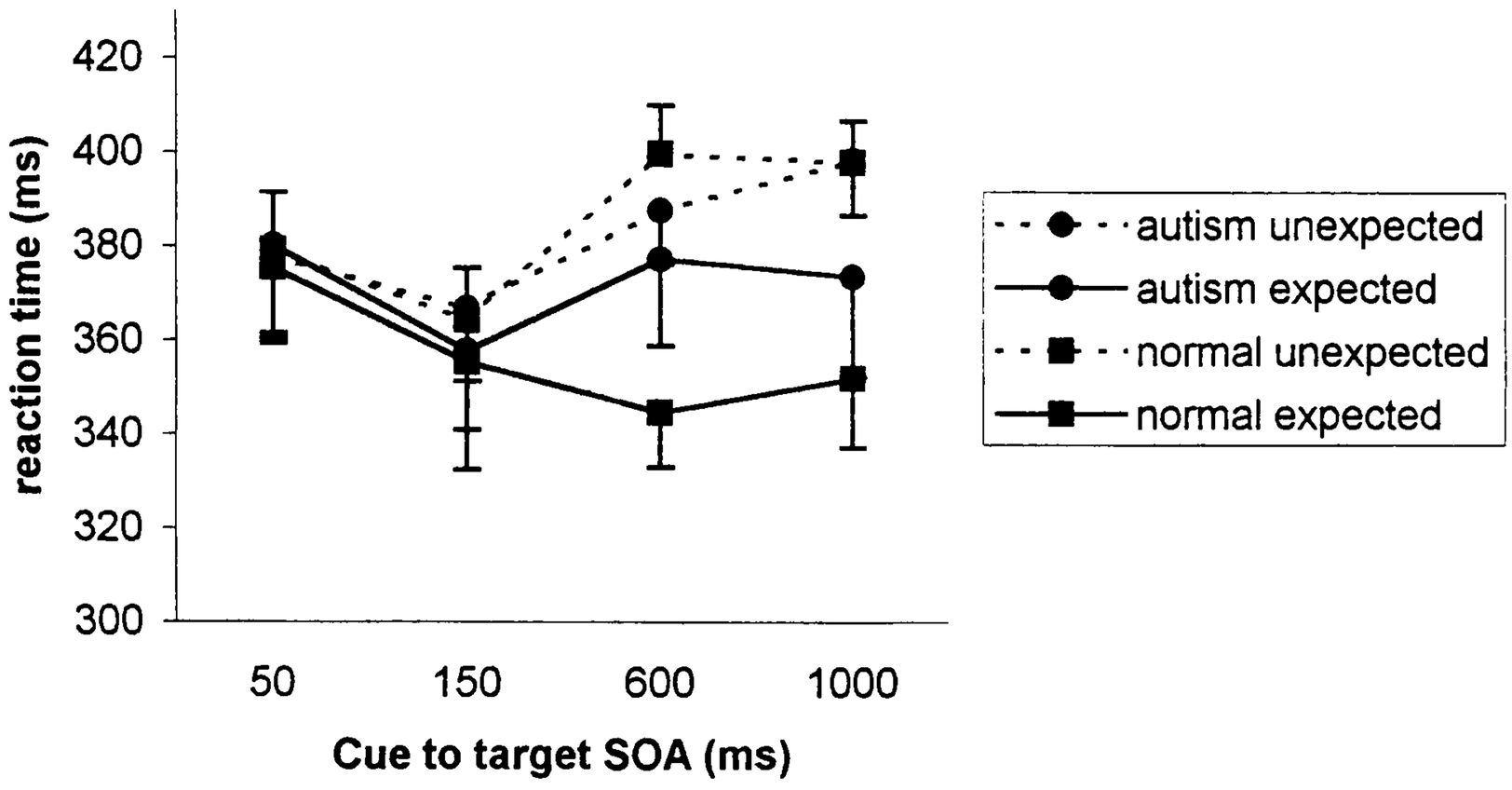


Figure 6.18. Mean reaction times in Experiment 6 to targets at varying intervals following an eye gaze directional cue (20% probability).

Validity effects

The data was treated as above. The scores from each group are shown in Figure 6.19. The analysis revealed a significant main effect of SOA [F (3,96)=7.20, p<0.001]. There were no significant differences between the two groups [F (1,32)=2.02, p>0.05]. The SOA by Group interaction approached significance [F (3,96)=2.40, p=0.07]. For completeness, planned comparisons were conducted at each SOA. These revealed a significant difference

between the two groups at a SOA of 600msec [t (32)=2.47, p=0.02] but not at SOAs of 50msec [t (32)=0.60, p=0.56], 150msec [t (32)=-0.01, p=0.99] or 1000msec [t (32)=1.01, p=0.32].

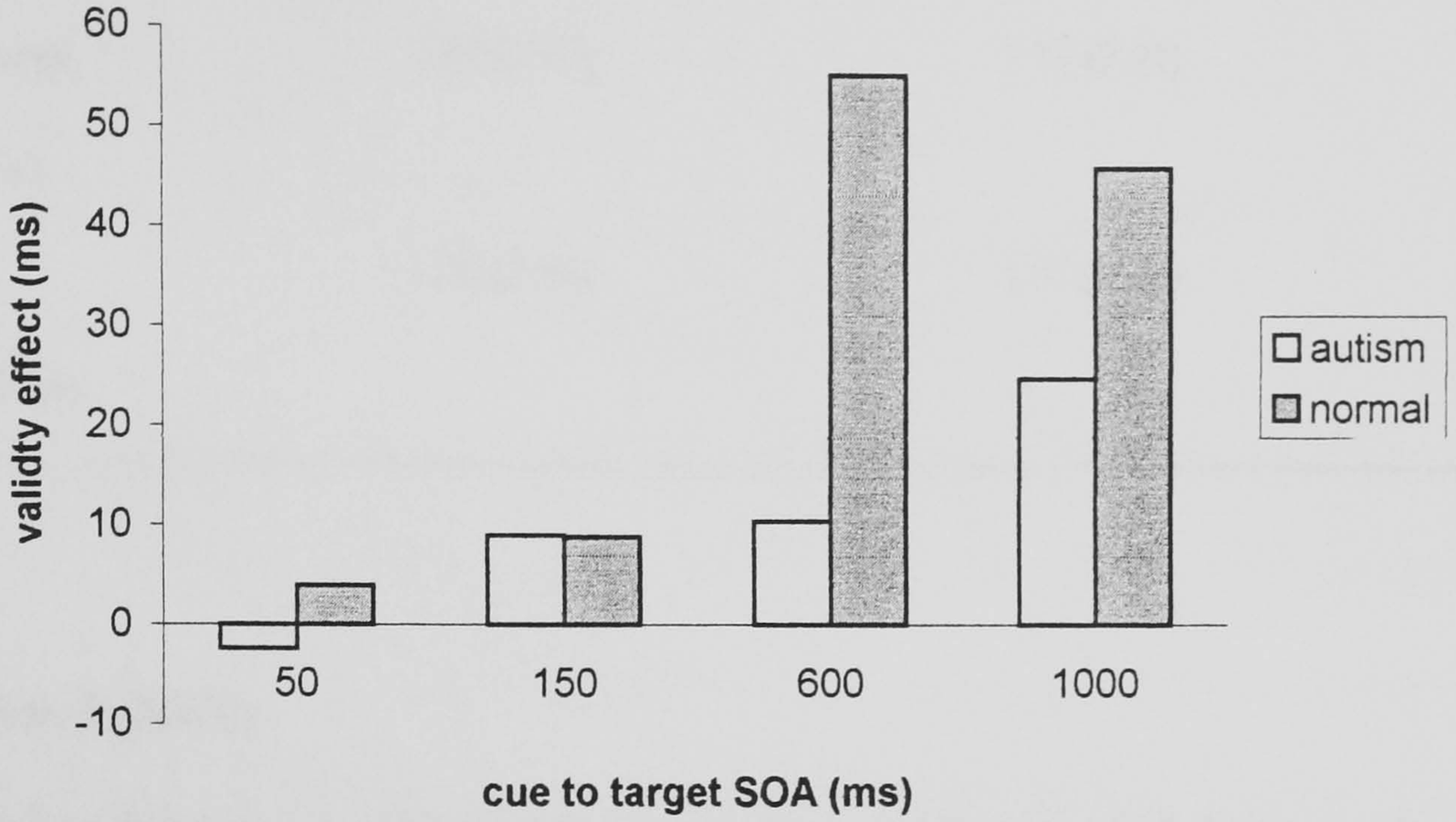


Figure 6.19. Validity effects (difference between expected and unexpected trials) in Experiment 6 following an eye gaze directional cue (20% probability).

Error Data

The mean (SD) number of errors was calculated for each group. Table 6.7 shows the error data for Experiment 6. Independent t-tests revealed no significant differences on either catch trials [t(32)=-0.118, p<0.907], false alarms [t(32)=-0.105, p<0.917] or misses [t(32)=0.496,p<0.623].

Table 6.7. Mean (SD) number of errors in both groups in Experiment 6.

	Normal	**Autism**
Catch (Response made)	1.24 (1.35)	1.18 (1.55)
False Alarm (RT < 100ms)	2.82 (3.52)	2.71 (2.97)
Miss (RT > 1200 ms)	1.00 (1.84)	1.35 (2.29)

6.14 DISCUSSION

In Experiment 6 the same stimuli as Experiments 1 and 4 were used, however the target was now four times as likely to appear on the side away from where the central face gazed than to appear on the side that the face gazed towards. Participants were explicitly instructed to try and direct their attention in the other direction away from the eye gaze cue. However, if people cannot suppress an automatic tendency to orient attention in the direction of seen gaze, we would expect that participants might still show an advantage on the side that the face gazed towards at the shorter SOA of 150ms as seen in Experiment 1. At the longer SOAs of 600 and 1000ms however, sufficient time should have passed to enable participants to push their attention endogenously to the other side where they expect the target to appear. In general the results from the comparison group support this prediction. While the validity effects were small at the shorter SOAs of 50 and 150ms these were greatly enhanced at the longer SOAs of 600 and 1000ms. In contrast the group with autism displayed reduced validity effects. This effect, although not statistically significant, approached significance and was reduced at the longer SOAs in the group with

autism, indicating that this group were having more difficulty using the eye gaze directional cue. This was most apparent at an SOA of 600ms, however by the longest SOA of 1000ms the individuals with autism were as proficient as controls in their ability to interpret the central eye gaze cue and direct their attention in the opposite direction.

6.15 RESULTS

Experiment 7 (Eye Gaze Cue- Modification of Experiment 1)

Reaction time

The median reaction time for each target delay and condition were calculated for each group. Figure 6.20 shows the mean RT for both the group with autism and the comparison group. This data were compared using ANOVA with a between subject factor of Group (Normal/Autism) and within subject factors of Cue (Congruent/Incongruent) and SOA (50,150, 600 and 1000ms).

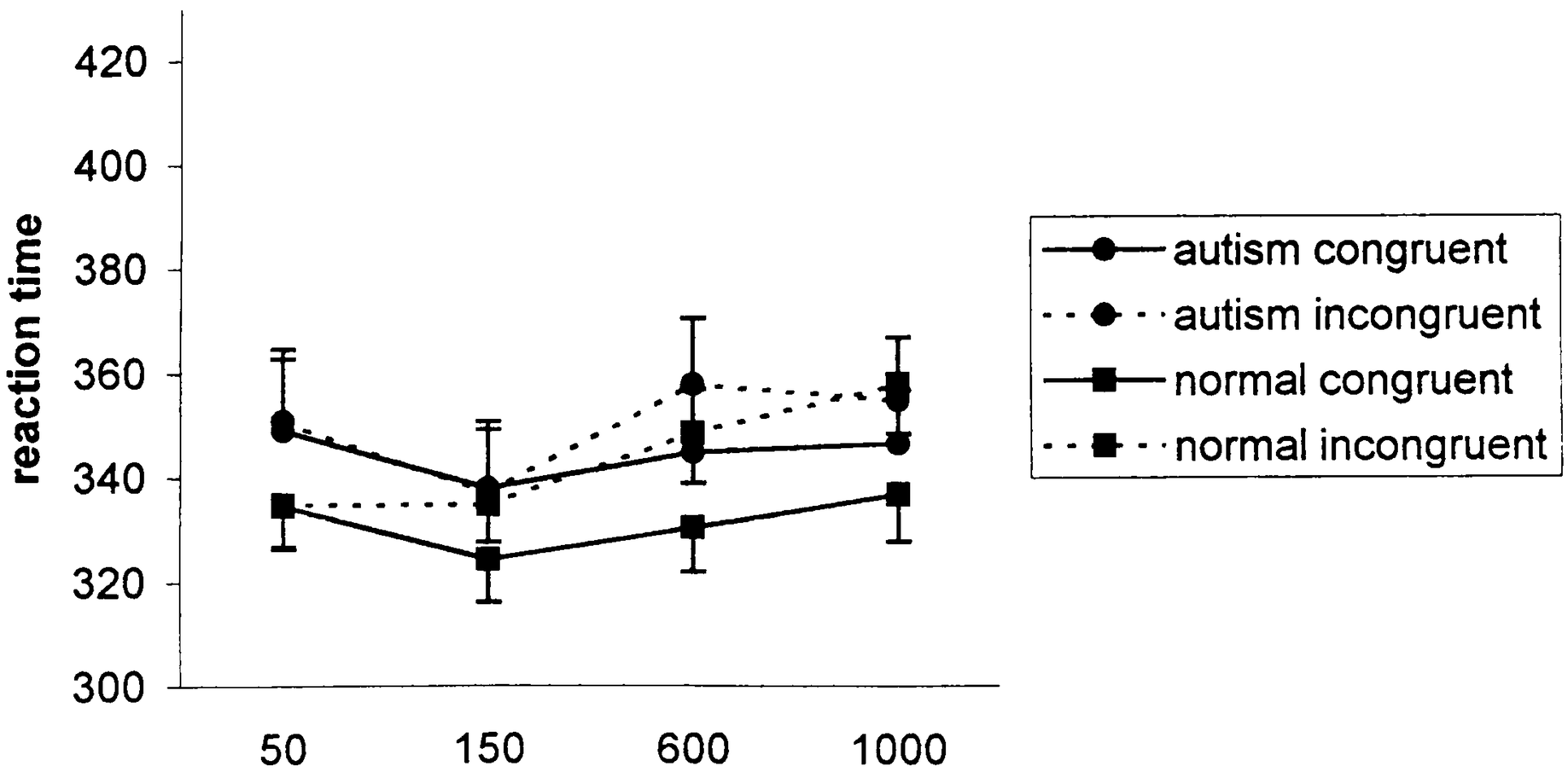


Figure 6.20. Mean reaction times in Experiment 7 to targets at varying intervals following an eye gaze directional cue. (50% probability) where the cue duration varied with SOA

There were no differences in overall reaction times between the two groups [F (1,30)<1, ns]. There was a main effect of Cue [F (1,30)=19.70, p<0.001], a main effect of SOA [F (3,90)=8.46, p<0.001] and a significant interaction between these two factors [F (3,90)=4.44, p<0.006]. Simple effect tests revealed that the source of this interaction was due to a significant effect of Cue at SOA's of 600ms [F (1,30)=14.68, p<0.01] and 1000ms [F (1,30)=12.95, p<0.01] but not at SOA's of 50ms [F (1,30)<1, ns] or 150ms [F (1,30)=1.38, p>0.05]. Similarly there was a significant effect of SOA for incongruent trials [F (3,90)= 8.65, p<0.01], but not for congruent trials [F (3,90)=2.38, p>0.05]. All other interaction terms were not significant (Cue by Group [F (1,30)=2.91, p>0.05], SOA by Group [F (3,90)=1.30, p>0.05] and Cue by Group by SOA [F (3,90)<1, ns]).

Validity effects

The data was calculated and compared as above. This analysis revealed a significant main effect of SOA [F (3,90)=4.44, p<0.006]. There was no significant effect of Group [F (3,90)=0.92, p=0.44] or any interaction between these two terms [F (1,30)=2.91, p<0.09]. Independent sample t-tests were calculated at each SOA. This revealed a significant difference between the two groups at an SOA of 150 ms [t (30)=2.13, p<0.04] but not at SOAs of 50ms [t (30)=-0.3, p<0.77], 600ms [t (30)=0.64, p<0.53] or 1000ms [t (30)=1.38, p<0.18]. Figure 6.21 shows the validity effect of each group at each SOA.

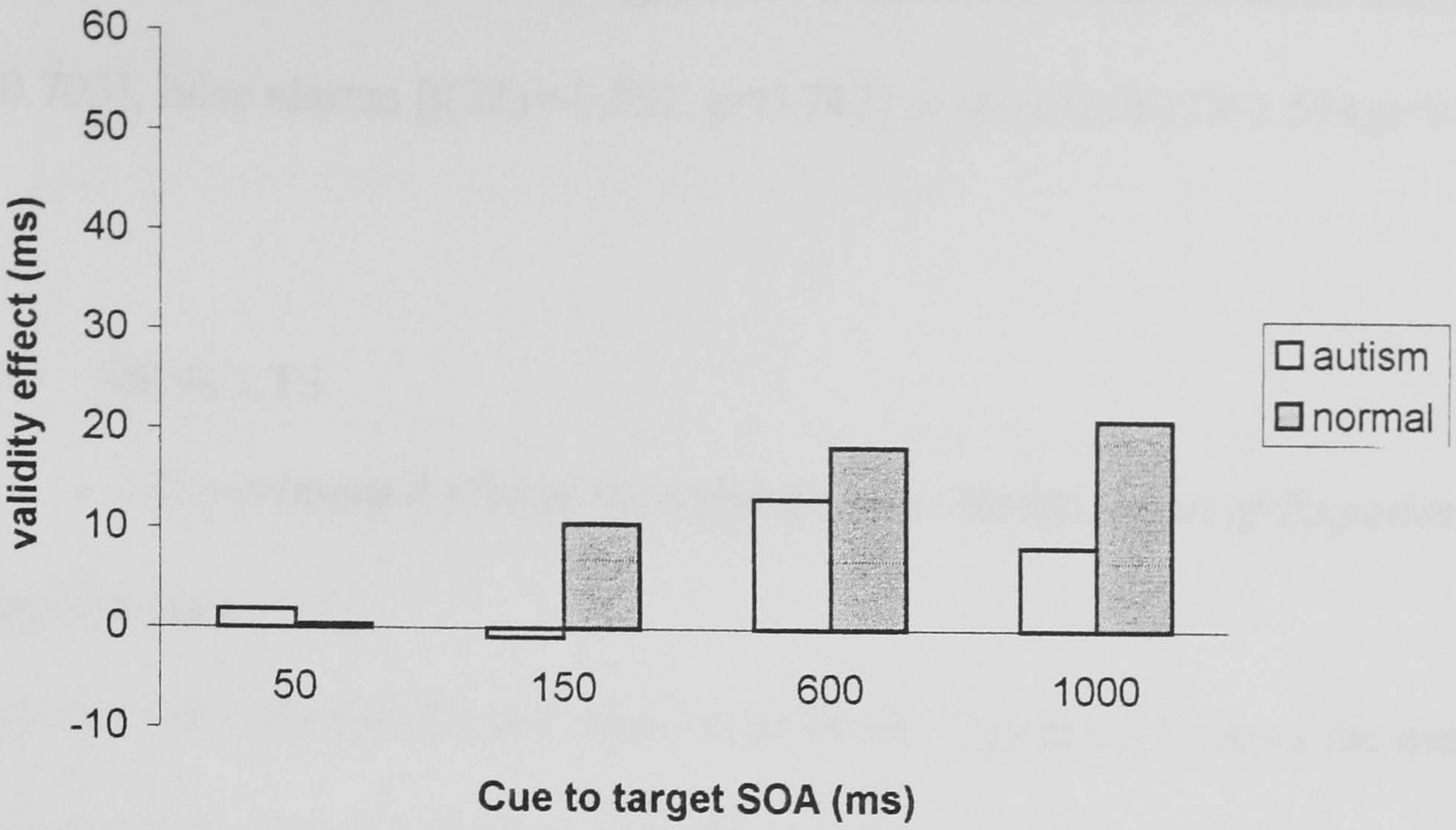


Figure 6.21. Validity effects in Experiment 7 (difference between congruent and incongruent trials) following an eye gaze directional cue (probability 50%) where the cue duration varied with SOA.

Error Data

The mean (SD) number of errors was calculated for each group. Table 6.8 shows the error data from Experiment 7.

Table 6.8. Mean (SD) number of errors in Experiment 7.

	Normal	**Autism**
Catch (Response made)	0.56 (1.15)	0.75 (1.57)
False Alarm (RT < 100ms)	1.63 (4.96)	1.19 (1.76)
Miss (RT > 1200 ms)	0.06 (0.25)	0.31 (0.60)

Independent t-tests revealed no significant differences on either catch trials [t(32)=0.385, p<0.703], false alarms [t(32)=-0.332, p<0.742] or misses [t(32)=1.534,p<0.136].

6.16 RESULTS

Experiment 8 (Head Directional Cue- Modification of Experiment 2)

Reaction time

This data was calculated and compared as above. Figure 6.22 shows the mean reaction times for both groups following a profile head directional cue that was correct 50% of the time. There were no differences in overall reaction times between the two groups [F (1,30=2.89, p>0.05]. There was a main effect of Cue [F (1,30)=20.25, p<0.001] and SOA [F (3,90)=4.92, p<0.003]. All other interaction terms were not significant. Cue by Group [F (1,30)= 1.59, p>0.05], SOA by Group [F (3,90)=1.56, p>0.05], Cue by SOA [F (3,90)=1.70, p>0.05] and Cue by SOA by Group [F (3,90)<1, ns].

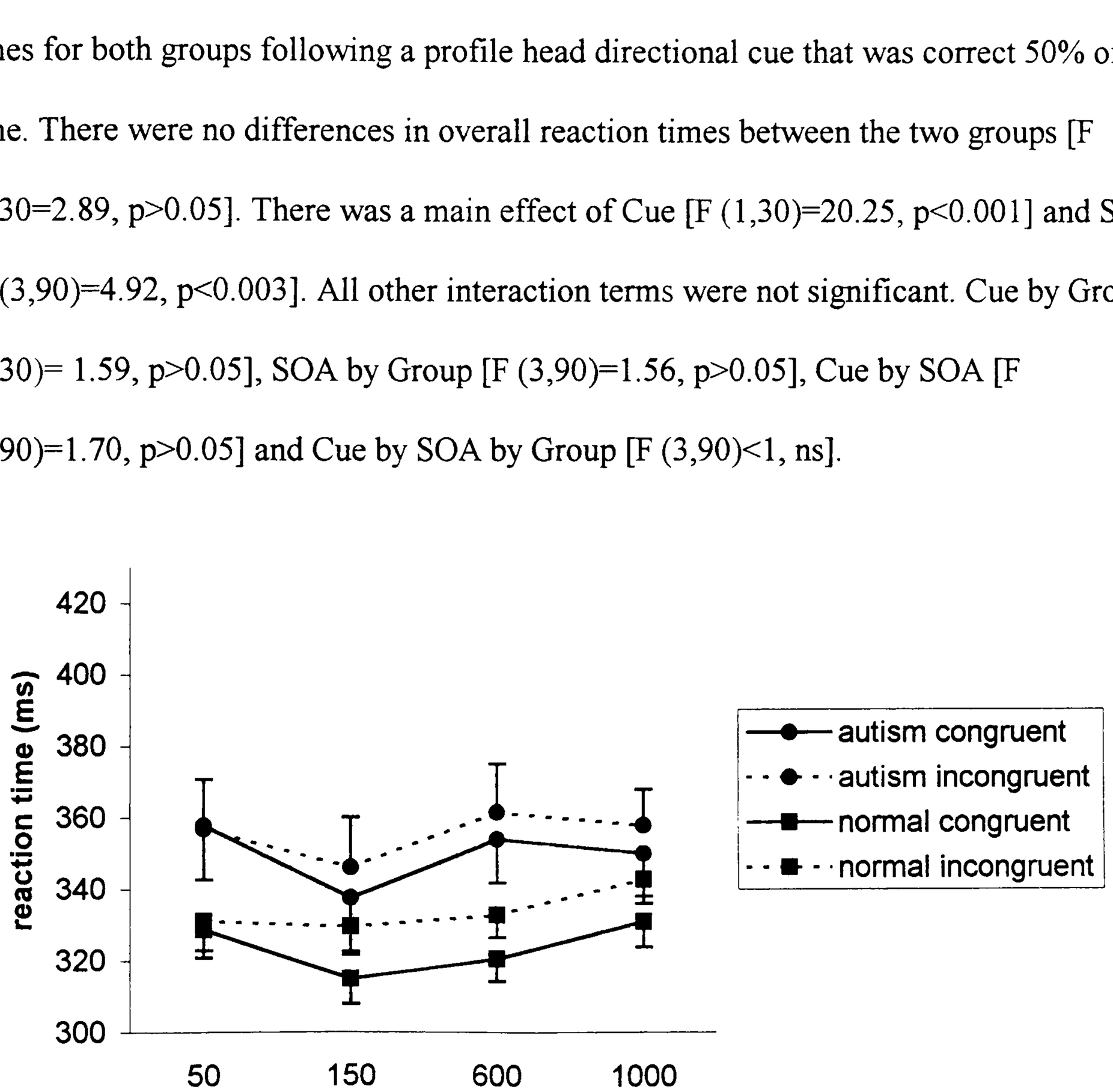


Figure 6.22. Mean reaction times from both groups in Experiment 8 to targets appearing at varying intervals following a profile head directional cue (50% probability) whose duration varied with SOA.

Validity effects

The data was calculated and compared as above. No significant results were found. (SOA [F (3,90)=1.70, p<0.17], SOA by Group [F (3,90)=0.03, p<0.99] and Group [F (1,30)=1.59, p<0.22]. Figure 6.23 shows the validity effect of both groups at each SOA.

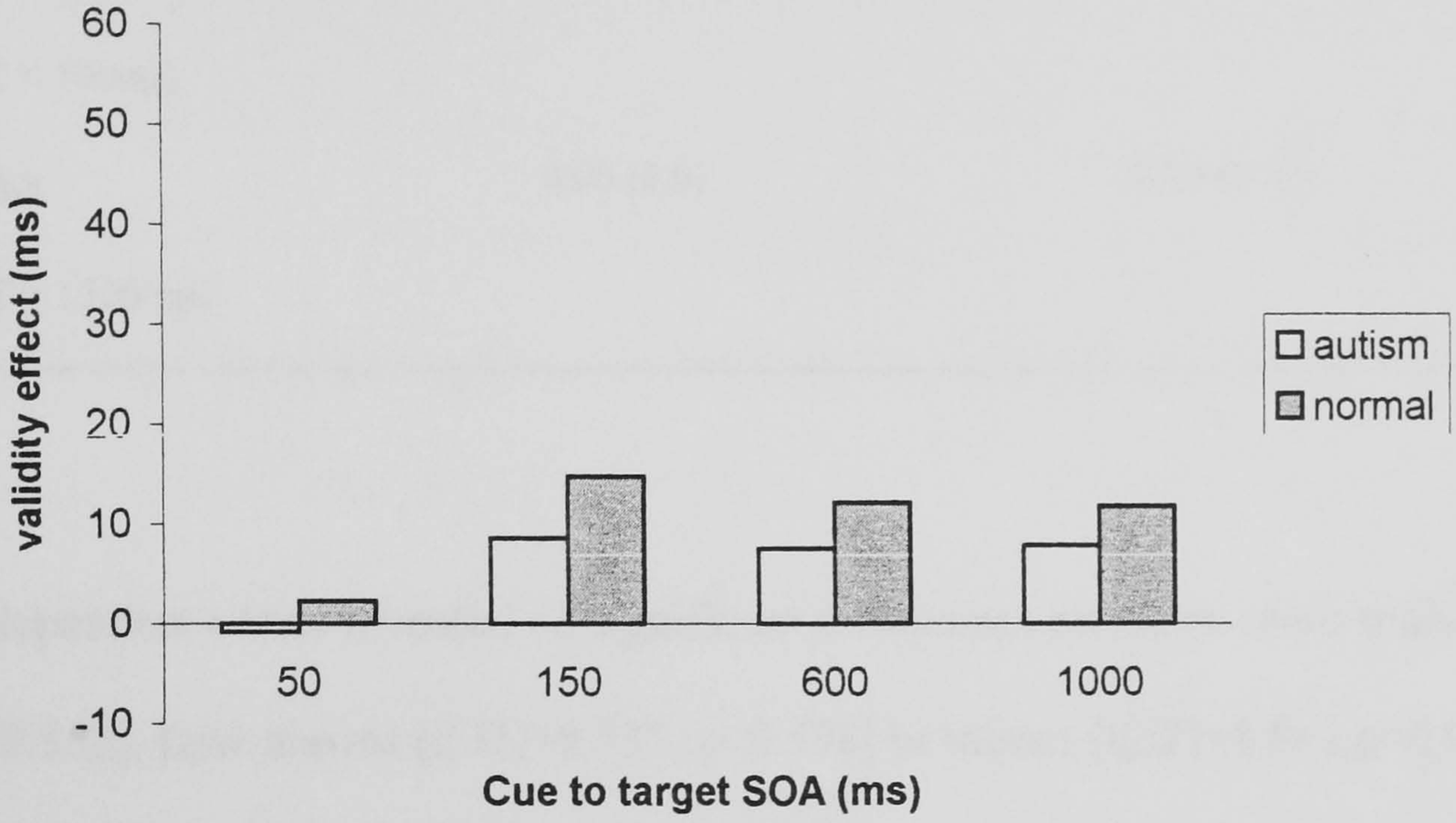


Figure 6.23. Validity effects in Experiment 8 (difference between congruent and incongruent trials) following a profile head cue (probability 50%) where the cue duration varied with SOA.

Error Data

The mean (SD) number of errors was calculated for each group. Table 6.9 shows the error data in Experiment 8.

Table 6.9. Mean (SD) number of errors in Experiment 8.

	Normal	**Autism**
Catch (Response made)	0.63 (0.72)	1.00 (1.41)
False Alarm (RT < 100ms)	1.00 (1.41)	1.44 (2.97)
Miss (RT > 1200 ms)	0.00 (0.0)	0.19 (0.40)

Independent t-tests revealed no significant differences on either catch trials [$t(32)=0.946$, $p<0.352$], false alarms [$t(32)=0.533$, $p<0.598$] or misses [$t(32)=1.861$, $p<0.073$].

6.17 DISCUSSION

Experiment 7 and 8

The main reason for conducting these two experiments was to investigate the shorter target detection latencies at the SOA of 150ms seen in experiments 1-5 in the group with autism. Because the cue duration in the previous experiments was also 150ms, we wondered whether target onset at cue offset gave an additional warning that the target was going to appear thus affecting RT or whether, given the range of SOAs, 150ms was the optimal time difference between cue and target for processing. This latter position was supported, as even when the cue duration varied, latencies were quicker at a SOA of 150ms in both the head and eye gaze experiments in both groups.

As in Experiment 1, the direction of gaze by the central face in Experiment 7 had a reliable effect on detection latencies even though the gaze was totally irrelevant to the task and provided no information about where the target letter was likely to appear. However the congruence effect on RTs interacted with SOA at 600 and 1000ms. This is in comparison to the earlier appearing effect at 150ms in Experiment 1. While this was taken to imply a relatively automatic orienting to gaze direction in Experiment 1, this is less attractive an opinion at the longer SOA's of 600 and 1000ms. In addition, the results of Experiment 8 are in direct contrast to those of Experiment 2. In the earlier experiment the profile head direction cue had no effect on target detection times, whereas in Experiment 8 a reliable effect of cue was found, thus showing that although the cues provided no information about where the target was likely to appear, target detection latencies were significantly faster on the side that the head cue gazed towards. Taken together, these results might suggest that, having completed Experiments 4-6 where one was required to attend to the central stimulus, this tendency is difficult to overcome in subsequent experiments.

6.18 GENERAL DISCUSSION

The main aim of this chapter was to investigate whether individuals with autism would show the relatively automatic or reflexive orienting response to social cues that has been reported for normal adults (Driver et al., 1999: Langton et al., 1999). The pattern of results has indicated that normal adults are unable to suppress an automatic tendency to orient their attention in the eye gaze direction (Driver et al., 1999) or head orientation (Langton et al., 1999) of others. In addition, the ability to use this social information voluntarily to direct their attention as efficiently as control subjects was explored. The results show that both the comparison group and the group with autism showed evidence of reflexive

orienting to the eye gaze direction of others (Experiment 1). Experiment 2 revealed that both groups of subjects were able to ignore the head directional cue, indicating that a laterally averted view of a head with a straight gaze did not produce fast automatic shifts in visual attention in either group. The reflexive orienting response to eye gaze direction was disrupted by the inversion of the stimuli in the comparison group. However the group with autism still showed a significant cueing effect when the eye gaze stimuli were inverted (Experiment 3). While the individuals with autism were overall slower than the comparison group in responding to targets in the first set of experiments (Experiment 1-3), these differences were no longer significant in the second set of experiments (Experiment 4-6). Greater practice effects or increased familiarisation with the experimental procedure among the group with autism were possible reasons proposed to account for this discrepancy.

There were also no significant differences between the group with autism and the comparison group in their ability to use a head directional cue when they were informed of the probable contingencies (Experiment 5). Experiment 4 did however reveal a difference in the group with autism's ability to use an eye gaze directional cue. While the normal control group were able to supplement their relatively automatic responses to seen gaze at the shorter SOA's of 50 and 150 ms, with an endogenous shift of attention at both the longer SOA's of 600 and 1000ms, the group with autism displayed a much reduced cueing effect. This difficulty in using information voluntarily derived from the eyes was further supported by the results of Experiment 6. When task demands required subjects to direct their attention in the opposite direction of the eye gaze cue, the individuals with autism were less able to do so with group differences apparent at a SOA of 600ms. Overall, the pattern of results reported in this paper would suggest that of the two 'social' cues investigated, information from a head directional cue was processed and used effectively

by the group with autism. While both groups showed evidence of relatively automatic processing of eye gaze direction, the individuals with autism were however, less able to make voluntary use eye gaze information.

It should also be noted that there was a SOA by Group interaction across experiments 1-5. This pattern of results indicated that the group with autism were showing significantly faster detection latencies at a SOA of 150ms. In the design of this study, cue duration was confounded with target onset at this SOA. Therefore two additional experiments (Experiments 7 and 8) were conducted to investigate whether cue offset coinciding with target onset provided an additional warning cue to shift attention, thus facilitating RT. These two experiments were similar to Experiments 1 and 2 except the cue duration coincided with variations in SOA. This manipulation removed the significant interaction, with optimal performance seen at 150ms in both groups. Thus it seems that given the range of SOAs in this series of experiments, 150ms was the optimal time difference between cue and target for processing.

The cueing effect seen in Experiment 1 bears some of the hallmarks of automatic or reflexive processes found in spatial cueing studies within the mainstream attention literature and as such could be taken as evidence for the idea that the brain has some innate mechanisms specific to gaze perception (Baron-Cohen, 1995). Specifically, Baron-Cohen (1995) has suggested that two modular mechanisms are involved in gaze following. One mechanism (the eye direction detector or EDD) is responsible for the perception of another's gaze direction. The second element (the shared attention mechanism or SAM) is responsible for executing shifts of the observer's own attention in the corresponding direction. The EDD is presumed to be intact in individuals with autism based on evidence that they are not impaired in the ability to make geometric judgements about the direction of perceived gaze (Leekam et al., 1997), whereas a malfunctioning SAM is said to be

responsible for their impaired ability to shift their own attention where others look (Baron-Cohen, 1995). On this account, individuals with autism are not impaired on the more mechanical aspects of perceiving where others are looking. However they are impaired on the more mentalistic aspects of interpreting the direction of seen gaze as reflecting the internal mental state of another person with unawareness of people as goal-directed beings capable of attending to objects.

While it is uncertain whether a digitised photograph could be interpreted in a mentalistic fashion, this account would still predict that the reflexive or automatic orienting response to seen gaze should be absent in individuals with autism. Clearly, this prediction was not supported by the results of this study. It could be argued that the cueing effect reported in this paper in response to the eye gaze direction of others might provide evidence for some aspect of the SAM to be intact.

However, mainstream attention studies have recently been criticised for not considering whether learned processes, operating over the lifespan could be involved in some of the spatial orienting effects that they have uncovered (Driver et al., 1999). These authors suggest that the well known effects following uninformative peripheral cues (Posner, 1980) might plausibly arise as a result of long-term learning that abrupt visual transients are often followed by important events at the same location in the real world. Recent research has provided some evidence of associative learning between cue attributes and target events (Lambert & Sumich, 1996). In this experiment, word cues were presented to the left and right of fixation. The semantic category of these words was predictive of the likely location of a subsequent target, however participants were unaware of the contingency between cue and target. Nevertheless, participants were faster to detect targets appearing in the cued compared to the uncued locations. It was suggested by Lambert and Sumich (1996) that the spatial orienting producing this effect was due to an implicit or

unconscious learning of the association between particulars of the cue and target events. Therefore the pattern of results obtained from the spatial cueing arising from seen gaze (Experiment 1) might operate as the result of extensive experience within social settings where seen gaze direction can often predict the location of important events. The inability to override this association might therefore arise because the tendency to orient in the direction of seen gaze is so heavily over-learned that it cannot easily be suppressed at will nor unlearned within the timeframe of the experiment. This may be a convincing explanation for the results of the normal adults who have had extensive experience within social settings, however it is a less attractive explanation for the individuals with autism whose social experiences have been more limited.

If the learning hypothesis is indeed correct, then individuals with autism might acquire the ability to orient to social cues, but with a slower time course than for typically developing individuals. The present results might be compatible with this delay hypothesis. The adult subjects with autism in the present study all attend a special residential provision for individuals with autism where extensive tuition on socialisation and communication is conducted with particular reference to the significance of eyes and eye gaze in the interpretation of social interactions. Coupled with the results of Experiment 4 and 6 where the individuals with autism were less able to use eye gaze voluntarily may suggest that an earlier deficit in reflexively orienting to the direction of seen gaze leaves one with a reduced ability to direct ones attention to the social signals of others at will. However, whether the fast relatively automatic orienting effects that we have observed in response to the eye gaze direction of others are the result of a learning process, or some kind of innate mechanism, as implied by Baron-Cohen (1994, 1995), is a difficult issue to resolve.

The results of Experiment 3 also point to abnormal processing of eye gaze in the group with autism. While use of inverted stimuli eliminated the cueing effect among the

control subjects, it did not among the individuals with autism. Two explanations were suggested. The result could be related to a lack of central coherence during face processing among the individuals with autism or alternatively their possible recruitment of object perception processes because of a lack of specialised face processing abilities (Schultz et al., 2000). On either account, one might expect that individuals with autism would show impairments in tasks requiring the processing of faces. While some studies have shown face recognition deficits in individuals with autism (Klin et al., 1999; Boucher & Lewis, 1992), others have failed to demonstrate any impairment (Davies, Bishop, Manstead & Tantan, 1994; Celani, Battacchi & Arcidiacono, 1999). However, one study has provided evidence for peculiarities in face processing that are not immediately apparent when only overall performance results are analysed (e.g., the lack of performance decrement when processing inverted faces and the preferential attention to the lower regions of the face rather than the eyes (Langdell, 1978)). While the conflicting results are difficult to reconcile it is possible that where results show no particular deficits in face recognition, older individuals with autism may supplement a possible lack of specialised areas dedicated to the perception of faces and compensate these with an intact object perception system. This may reveal no difficulties on a given experimental task, where stimuli are presented for long periods, however this strategy may be less effective in a naturalistic setting where face processing involves stimuli that appear for very short periods, that shift at a very fast pace and that need to be intuitively and quickly integrated with other social information such as voice intonation and posture.

The results of Experiment 2 using head orientation as the directional cue, showed no cueing effect in either group. These results are not concordant with those of Langton et al. (1999). However another study (Hietanen, 1999) has also failed to report cueing effects as the consequence of a head directional cue. This author reported that a profile head cue

with a compatible gaze did not affect response times, indicating no specific automatic response to the direction of the head. In contrast a frontal face with an averted gaze did produce cueing effects. He further implies that psychologically a frontal view of a face could provide a more powerful social signal. The fact that both groups showed comparable results in Experiment 2 and 5 where subjects had to ignore and attend to the profile head cue respectively would suggest that the individuals with autism were only having difficulty in using information derived from the eyes.

While it is difficult to ignore the significance of eye gaze (Kleinke, 1986), the relative importance of eye gaze and head direction in the analysis of social attention has recently been raised. Perrett and Emery (1994) have suggested that an eye-direction detector (Baron-Cohen, 1995) forms only part of a system designed to compute the direction of social attention. Perrett and his colleagues have proposed the existence of a direction of attention detector (DAD), which combines information from separate detectors analysing the direction of the eyes, head and body. These are arranged in a hierarchical fashion so that information from the eyes will override any information provided by the head, which in turn can override directional signals from the body. However, recent evidence suggests that information from the orientation of the head is not completely suppressed when it conflicts with the line of regard of the eyes (Langton, in press) and that while acknowledging the priority of the eyes as an indication to the direction of another person's attention, other cues such as head orientation and pointing gestures make significant contributions as well (Langton, Watt & Bruce, 2000). Given that the results reported in this chapter would suggest that the individuals with autism have difficulty with eye gaze use, it may be interesting to investigate the relative importance that they devote to eyes, head or body orientation and perhaps pointing gestures in the analysis of social attention.

In conclusion, the results of the experiments reported here would suggest that individuals with autism are not globally impaired in responding to social cues. While there was no evidence of a relatively automatic orienting response to head orientation in either group, the individuals with autism were able, when instructed, to use these cues as effectively as the comparison group. In contrast, both groups displayed a similar relatively automatic orienting response to eye gaze direction, however the effect was more short lived in the group with autism suggesting that this group were impaired in using information derived from the eye voluntarily. It was suggested that perhaps this impairment stems from a delay in acquiring a reflexive response to eye gaze during development. This is, of course, speculative and will remain so until tasks of this type are conducted with much younger individuals with autism.

CHAPTER 7

The effect of eye gaze versus head orientation in the analysis of social attention

7.1 INTRODUCTION

Previous research has emphasised the importance of the eyes in the analysis of social attention. For example, Perrett et al.'s (1992) direction-of-attention detector (DAD) is a mechanism that analyses the direction of the eyes, head and body to determine where another individual is directing their attention. This is achieved by a network of inhibitory connections, however the eyes hold primary importance. Baron-Cohen (1994; 1995) also places particular emphasis on the eyes in his 'mind-reading system' to account for the processes involved in social cognition. Conversely, other evidence would suggest that the perception of another's attention relies more on the head than eye gaze (Maruyama & Endo, 1983; Anstis et al., 1969). More recently, Langton (submitted) has proposed that both head and eyes have an equally mutual influence on decisions concerning the direction of social attention.

The results of the previous chapter reported that individuals with autism showed some evidence of difficulties using information derived from the eyes. Coupled with the fact that numerous studies have suggested that gaze processing is impaired at many different levels in individuals with autism, such as eye contact (Kanner, 1943), gaze following (Leekam, Hunniset & Moore, 1998), joint attention (Charman, Swettenham, Baron-Cohen, Cox, Baird & Drew, 1997) and understanding gaze within a mentalistic framework (Leekam et al., 1997; Baron-Cohen, Campbell, Karmiloff-Smith et al., 1995;

Baron-Cohen, Wheelwright & Jolliffe, 1997), it was deemed of interest to investigate the relative importance of eye gaze versus head orientation in the analysis of social attention among individuals with autism.

This chapter reports on the results of an interference paradigm adapted from Langton (submitted). The rationale behind using an interference paradigm as in the McGurk effect (McGurk & MacDonald, 1976) or the Stroop colour-word task (Stroop, 1935) is that by placing different dimensions into conflict it is possible to examine any possible interactions between them. In the experiment reported in this chapter, participants were presented with a photograph of a female whose head was oriented to the left or the right. However, the gaze direction of the stimulus was either in a congruent or an incongruent line of regard to her head. Participants were asked to make a speeded response to each of these signals in separate blocks of trials. For example, in one block of trials a subject might be asked to respond to the orientation of the head and ignore the direction of the eyes and in the other block of trials, responses to the eye gaze direction were required while ignoring the direction of the head.

It was predicted that the individuals with autism would show a preference in processing the head orientation thereby eye gaze and head orientation were expected to produce asymmetric interference effects. That is, the processing of the eye direction would be influenced by the direction of the head orientation, but classification of the head orientation would be unaffected by the direction of the accompanying gaze.

In contrast, for the normal individuals several predictions were possible. Predictions based on Perrett et al.'s (1992) direction of attention detector would suggest that eye gaze direction will always inhibit head orientation but not vice-versa. Therefore, the opposite pattern of results to the individuals with autism would be predicted, with processing of the head orientation influenced by the direction of the accompanying gaze,

but classification of eye-gaze direction would be unaffected by the orientation of the head. If, on the other hand, head orientation plays a more significant role in the analysis of social attention direction as Langton (submitted) would suggest, a more symmetrical pattern of effects might be predicted.

Conversely, results based on the findings of Maruyama and Endo (1983) might suggest that processing of gaze direction will be influenced by head orientation but processing of head orientation will not be influenced by the eye gaze direction, which would produce asymmetrical results again, but in the opposite direction as those based on Perrett et al's (1992) model.

These predictions would be the same as those made for the individuals with autism. If this were the case, one might still expect that the individuals with autism would have difficulty using the eye gaze direction thereby displaying more errors and longer reaction times than the comparison subjects on the block of trials where one is required to respond to the eye gaze direction and ignore the head direction, whereas no differences in either errors or reaction times would be predicted on the respond to the head orientation and ignore the eye gaze direction block. Given all these possibilities, no definite predictions were made regarding the results of the comparison group.

7.2 METHOD – Study 4

Participants

16 participants from each group who took part in the social cueing experiments described in the previous chapter were available for re-testing approximately 4 months later. Participants' characteristics are shown in Table 7.1. Independent sample t-tests revealed that the chronological ages, VIQ, PIQ and IQ of the two groups were not significantly

different ([t (30)=-0.80, p<0.43], [t (30)=-0.67, p<0.51], [t (30)=0.10, p<0.93] and [t (30)=-0.19, p<0.85]) respectively.

Table 7.1. Participant characteristics

Group	N		AGE(y:m)	VIQ	PIQ	Overall IQ
Autism	16	Mean	20.56	88.25	91.50	89.31
		SD	2.47	14.88	19.46	15.96
		Range	16.9-23.9	73-112	72-123	72-118
Normal	16	Mean	21.06	90.94	90.93	90.19
		SD	1.66	6.25	13.64	8.71
		Range	16.9-26.0	75-110	75-120	75-114

Stimuli and Apparatus

The apparatus was the same as in the previous experiment. The visual stimuli for this task consisted of four digitised images of a female face. These images were 9 cm in height and 7 cm in width and were viewed by participants seated approximately 57cm from the monitor. In each of these images the head was oriented approximately 30 degrees to the left or to the right of centre with the direction of eye gaze oriented approximately a further 15 degrees in the same or opposite direction of the head. In half of the trials, the eye gaze was directed in the same direction as the head orientation (congruent trials), the other half of the trials the eyes were gazing in the opposite direction to that of the head (incongruent trials). In accordance with Langton (submitted), the amount of visible sclera in the congruent and incongruent images was roughly equated. The left and right gaze cues were

produced by a mirror reflection to ensure symmetry between stimuli. Figure 7.1 shows an example of the experimental stimuli.

1 2 3 4

Figure 7.1. Examples of the experimental stimuli. Picture 1 and 2 show an incongruent eye gaze and head direction. Picture 3 and 4 show congruent eye gaze and head direction.

Design

The experiment had a mixed design, with one between subjects factor of Group (Normal/Autism) and within subject factors of Response dimension (head or eye) and Congruity (congruent/incongruent). An experimental session consisted of 2 blocks of 160 trials with a short rest break after 80 trials. The direction of the image was equally divided between looking to the right and left and randomly distributed within each block. In one block of trials participants responded to the orientation of the head and were asked to ignore the gaze, and in the second block of trials they responded to the gaze direction and were asked to ignore the orientation of the head. The order in which these blocks were presented was alternated between successive participants. The image remained on the

screen until the participant responded and was then followed by a 500msec inter-trial interval.

Procedure

Testing of individuals took place in an interview room at the participant's institution.

Participants were asked to respond as quickly and accurately as possible to either the gaze or head direction of the visual stimulus, which would appear in the centre of the screen. Participants executed their responses by depressing one of two buttons on a button box, the right button signalling a right decision and the left button signalling a left decision. Depression of either key terminated the presentation of the visual stimulus and stopped the timer. Following the response, the screen remained blank for 500msec before the start of the next trial. Participants received 16 practice trials, comprising four repetitions of each of the four experiment stimuli before the start of the experiment. Reaction times (RTs) and the number of errors were recorded.

7.3 RESULTS

All reaction times greater than 2000ms and less than 100ms were removed. Figure 7.2 shows the mean correct reaction time for both groups of subjects on congruent and incongruent trials when participants were told to respond to the direction of the eyes and ignore the head direction. This shows that participants from both groups were faster to respond on congruent compared to incongruent trials.

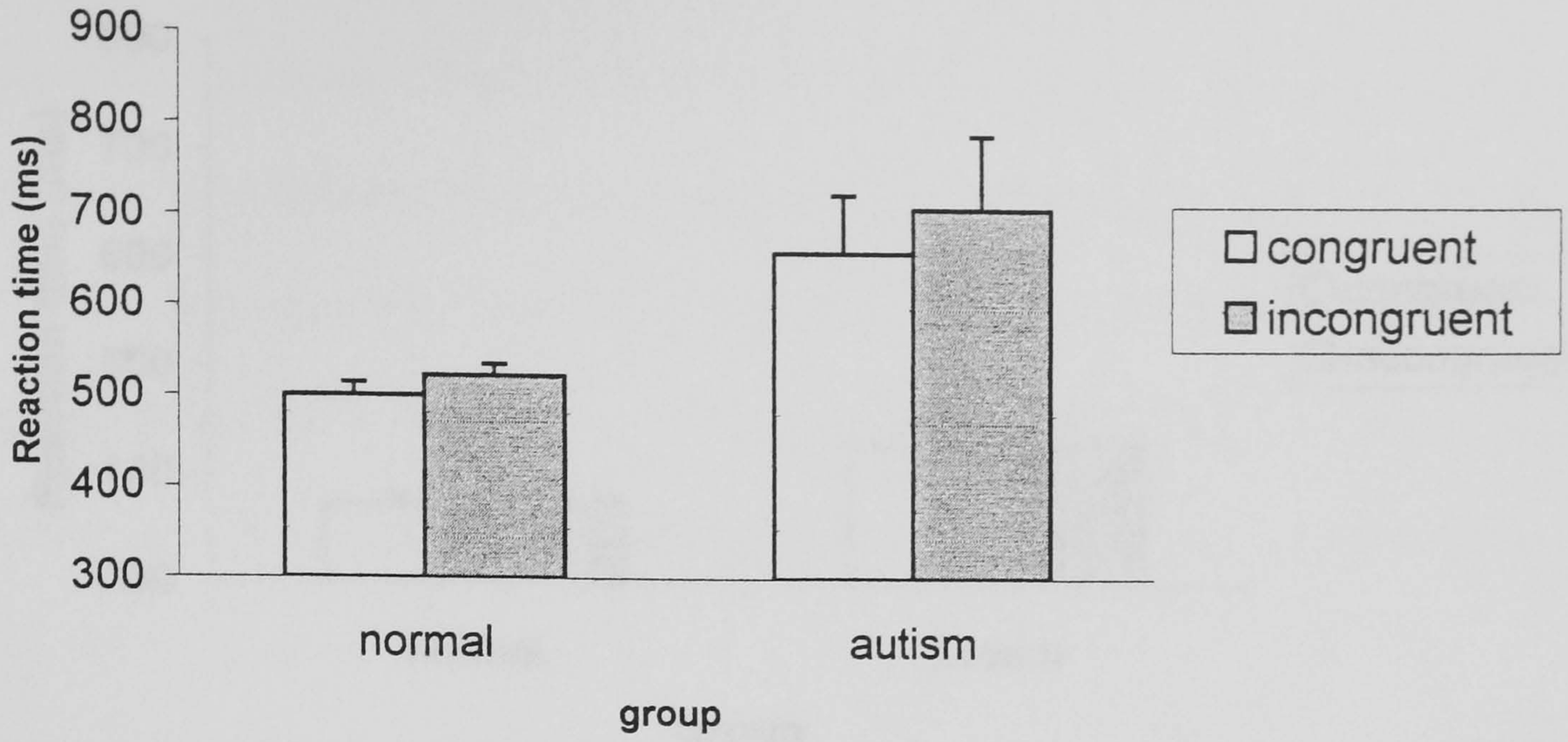


Figure 7.2. Mean (SEM) reaction times for both groups on congruent and incongruent trials in response to gaze.

Figure 7.3 shows the reaction time for both groups of subjects on congruent and incongruent trials when participants were told to respond to the direction of the head and ignore the eye direction. This figure shows that there were no differences in responses to either congruent or incongruent trials. Both groups showed this pattern of results.

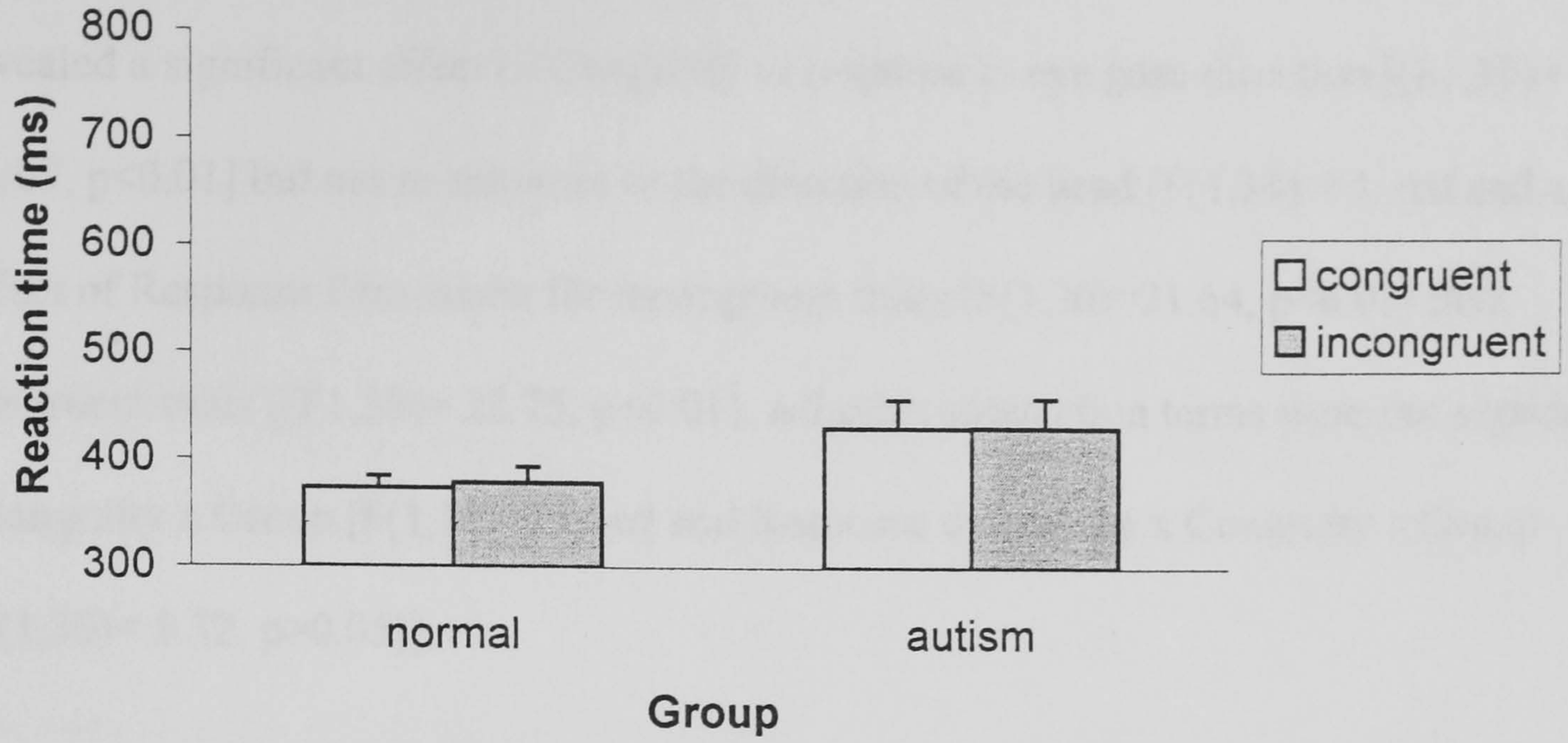


Figure 7.3. Mean (SEM) reaction times for both groups on congruent and incongruent trials in response to head direction.

There are clear effects of congruity for responses to eye gaze direction but no effect of congruity in response to the direction of the head. These observations were confirmed by an ANOVA examining Congruency and Response dimension as factors affecting reaction time in both groups. This analysis revealed a main effect of Response dimension [$F(1,30)=54.02$, $p<0.001$], indicating faster response times to head direction, a main effect of Congruency [$F(1,30)= 9.57$, $p<0.004$] indicating faster reaction times on congruent trials and a main effect of Group [$F(1,30)=5.37$, $p< 0.03$] with the comparison group significantly faster to respond. There was a significant interaction between Response Dimension and Group [$F(1, 30)=4.83$, $p<0.04$] suggesting that the group with autism were additionally slower to respond to the eye gaze direction than to the direction of the head. Simple effects analyses confirmed this observation. There was a more significant effect of Response dimension for the group with autism [$(F1,30)=45.57$, $p<0.01$] than the

comparison group [(F1,30)=13.29, p<0.05]. The main effect of Congruity was further qualified by a significant interaction with Response Dimension. Simple effects analyses revealed a significant effect of Congruity in response to eye gaze direction [(F1,30)= 16.09, p<0.01] but not in response to the direction of the head [F(1,30) < 1, ns] and a larger effect of Response Dimension for incongruent trials [F(1,30)=31.64, p<0.01] than congruent trials [(F1,30)= 22.75, p<0.01]. All other interaction terms were not significant (Congruity x Group [F(1,30) < 1, ns] and Response dimension x Congruity x Group [F(1,30)= 1.32, p>0.05]).

Error data

For both groups, rates of errors were low in the respond to head direction condition, with more errors made in the respond to eye gaze direction. Table 7.2 shows the mean percentage of errors from both groups in both conditions. The mean percentage of error scores were analysed using ANOVA with a between subject factor of Group and within subject factors of Response dimension and Congruity. This revealed a main effect of Group [F(1,30)= 6.66, p<0.01] and Congruity [F(1,30)=22.51, p<0.001] which was further qualified by a significant interaction between Congruity and Group [F(1,30)=7.57, p<0.01] and Response dimension and Congruity [F(1,30)=5.11, p<0.03]. Simple effects analyses revealed that the Congruity X Group interaction was attributed to a significant effect of Congruity for the group with autism [F(1,30)=32.99, p<0.01], but not the comparison group [F(1,30)=1.41, p>0.05]. The Response dimension x Congruity interaction was attributed to a significant effect of Congruity for the respond to gaze direction condition [F(1,30)=24.09, p<0.01] and not the respond to head direction condition [F(1,30)=3.26, p>0.05]. All other main effects and interaction terms were not significant (Response

dimension [F(1,30)= 2.73, P=0.11], Response dimension x Group [F(1,30)= 0.92, p=0.35], Response dimension x Congruity x Group [F(1,30)= 3.42, p=0.07]).

Table 7.2. Mean RT (ms) and percentage of errors for each group in each condition.

Response to gaze				
	Reaction time (ms)		**% of errors**	
	Normal	**Autism**	**Normal**	**Autism**
Congruent	500.53	658.56	0.82	1.56
Incongruent	522.47	706.50	1.40	4.38
Response to head				
	Reaction time (ms)		**% of errors**	
Congruent	373.41	431.09	0.59	1.29
Incongruent	378.69	432.13	0.98	2.15

7.4 DISCUSSION

The results of this experiment demonstrated that participants' responses to the orientation of another individual's head were not influenced by the direction in which this individual was gazing. Reaction times from both groups to the direction in which the head was oriented were comparable when the eyes were gazing in the opposite direction to the head with the condition in which the eyes and head were oriented in the same direction. In contrast, a congruity effect was noted when participants were asked to respond to the eye gaze direction and ignore the direction of the head. In other words responses to head orientation were not influenced by the to-be-ignored eye-gaze direction, however responses to gaze orientation were influenced by the irrelevant orientation of the head. This would

suggest that for both groups the head orientation held the greater role in the direction of attention detection.

These results are in accordance with those reported by Maruyama and Endo (1983) who showed that subjects' perception of the direction of gaze in schematic faces was intermediate between the eyes' line of gaze and the orientation of the face. Their data also suggested that the processing of gaze direction was influenced by head orientation, but processing of head orientation was not influenced by the perception of gaze direction. These results are however, contrary to those predicted by either Baron-Cohen's (1994) EDD or Perrett et al.'s (1992) DAD models. These models emphasise the importance of the eyes in the analysis of social perception, therefore one would expect to see a greater congruity effect in response to head orientation while ignoring the eye gaze direction based on predictions derived from these models. The results reported in this study show the opposite effect. They are also not concordant with results reported by Langton (in press), who found congruity effects that were symmetrical in nature; responses to head orientation were influenced by the to-be-ignored gaze dimension to the same extent as classification of eye-gaze direction was influenced by the irrelevant orientation of the head, thus suggesting the mutual influence of head and gaze direction in social attention detection.

While the debate over the relative importance of one cue over the other remains, the discrepancy between the results reported in this study and those reported by Langton (submitted) may be reconciled. Although the interference paradigm adopted in this study was adapted from that reported in the Langton study, there was one important difference. In the Langton study the photographic images of a head included both orientations in the horizontal and the vertical planes, thus both the congruent and incongruent 'looking' downward photographs contained images where the eyes were occluded. This, according to Perrett et al.'s (1992) DAD model would suggest that head orientation would over-ride

eye gaze direction, therefore this influence may have confounded the reaction time data. In the study reported in this chapter, only responses in the horizontal plane were examined. While this may have eliminated one possible confound, it may have introduced another. By only using images with attention directed in the horizontal plane, subjects could be using the nose as a directional cue in the respond to head block of trials thereby excluding any need to process the eye direction at all. This then could account for the asymmetrical congruency effects found in response to gaze and head direction. It may also point to common sense predictions that eye-gaze and head orientation may have different influences on social attention direction detection based on differing task demands. For instance, if you are engrossed in conversation on a mutual topic of interest, or alternatively, if you suspect that the other person was trying to deceive, you might pay particular attention to another's eyes. On the other hand, when socialising in a group or with others from a distance, the realisation that someone has lost interest may be better determined from a change in head orientation.

While this study failed to resolve the issue of the relative importance of eye-gaze and head direction in the analysis of social attention direction, there were important differences highlighted between the groups. As predicted the group with autism displayed significant difficulty in responding to the eye gaze direction while ignoring the head orientation. This was based on the significant interaction between Response dimension and Group. While both groups were faster to respond to the direction of the head, this interaction suggests that the group with autism were having additional difficulty in responding to the eye gaze direction. Analyses of the error data are also suggestive of difficulties in processing eye gaze among the individuals with autism. The pattern of results suggest that incongruent trials elicited the most errors and these were more likely in the respond to gaze direction, however the effect of congruity was most evident in the

individuals with autism. These results therefore support the suggestion from the previous chapter that the individuals with autism have difficulty in using information derived from the eyes.

7.5 RATIONALE FOR FINAL EXPERIMENTAL CHAPTER

In Chapter 2 it was suggested that an attention-shifting impairment could account for the behavioural manifestations found in autism (Courchesne et al., 1994). However, previous studies supporting an attention-shifting impairment hypothesis of autism were beset with methodological difficulties. The experiments in Chapter 3 and 4 were designed to address these problems. The results from the experiments reported in Chapter 3 would suggest that individuals with autism do not have difficulties in shifting attention covertly in either the voluntary or reflexive modes. Moreover, the pattern of results from the visual search tasks reported in Chapter 4 are not indicative of an attention shifting impairment in autism. It was suggested therefore that the lack of joint attention behaviours seen in younger individuals with autism could stem from difficulties in interpreting social signals as cues to objects or situations of interest, rather than to difficulties in the voluntary control of their attentional system. While this thesis does not directly address this issue, the results reported in this chapter and Chapter 6 using older individuals with autism indicated that, of the two social signals that were investigated, using information from the eyes was particularly difficult. There was something about the nature of the cue rather than an attention-shifting impairment that was contributing to the individuals with autism's performance. That this was not due to an attention-shifting impairment was further supported by the results that showed a comparable performance when reflexively shifting to an eye gaze cue and also their ability to shift attention voluntarily to the cued head direction of another. Thus it seems that in this sample of older individuals with autism, using eye gaze information was problematic.

While it is important to respond to the shift of another's eye gaze direction during social interactions, it is equally important to be sensitive to frontal eye gaze. Chapter 8 investigates the ability of individuals with autism at perceiving frontal eye gaze using a forced choice detection task (Perrett et al., 1986).

CHAPTER 8

Gaze Perception

8.1 INTRODUCTION

The evidence reviewed in chapter 5 suggests that it would be of significant adaptive advantage for animals and humans to be sensitive to changes in another's attention. However, it is equally important to be attentive to frontal eye gaze. For social animals, sensitivity to direct gaze may be used as a defence against predators, to display threat or dominance or to express attraction in the presence of a potential mate. While humans use and interpret direct gaze to affirm desire and intimacy and as a cue for turn taking in conversation, prolonged gaze from a stranger elicits the same feeling of threat or dominance as it does among animals (Kendon, 1967).

Social and developmental psychologists have examined the functional significance of gaze in the control of social interactions (Kleinke, 1986), the development of gaze following (Hood et al., 1998) and its relationship to joint attention behaviours and mental state attribution (Baron-Cohen, 1995). In contrast, perceptual psychologists have looked at thresholds for gaze detection to try and determine the accuracy with which we can decide whether we are being looked at (Anstis et al., 1969; Cline, 1967; Wade & Jones, 1982). Anstis et al. (1969) have shown that the human perceptual system is highly sensitive to deviations from frontal view when photographs of faces are viewed. They estimate that at a viewing distance of 122cm, a horizontal displacement of the iris of just 0.18mm is noticeable to subjects. This suggests that good visual acuity makes a significant contribution in the ability to make fine discriminations between the contrast of the coloured iris and the white sclera in the perception of direct gaze.

In the previous two chapters, it has been suggested that individuals with autism have difficulty using information derived from the eyes. While the evidence from Chapter 6 suggested that the individuals with autism showed a similar reflexive or relatively automatic orienting response to eye gaze direction as normal adults, they were impaired in using this information at will. Moreover, they were significantly slower in responding to an eye gaze direction cue and made more errors when these cues were in conflict with the orientation of the head as reported in Chapter 7. As mentioned earlier, while it is important to note and respond to changes in another's attention direction, it is also important to be able to detect direct gaze. This chapter reports a study to determine accuracy at perceiving frontal eye gaze by using a forced choice detection task on paired photographs of a single human face (Perrett et al., 1986).

While an impaired ability at detecting mutual gaze may be adding to individuals with autisms' difficulties in social interaction and communication, it is important to determine that something like poor visual acuity or an inability to make fine discriminations does not contribute to this difficulty. To exclude the possibility of impairments in making fine discriminations contributing to possible impaired performance, or circular accusations such as less experience in social interactions resulting in an impaired ability to detect eye gaze direction, a control task was employed in Experiment 1. This test involves subjects viewing a series of photographs in which a person is looking at one of three possible rods. Subjects are asked to indicate which rod the person in the photograph is looking at. The task gets increasingly more difficult as the spacing between the rods diminishes.

One study has previously used a variation of this control task. Leekam et al. (1997) tested children with autism's ability to discriminate degrees of change in the orientation of gaze and conclude that the children with autism were well within their developmental age

level on this task. Twenty relatively low-functioning children with autism (mean age 13.5 years) and two groups of mental age matched control subjects were tested on half of the original test devised by Perrett and Milders (1992). Only the coarser separations of twenty and ten degrees were used in the Leekam et al. study as pilot work had revealed that participants were at chance level on the two finer discriminations of five and two degrees. The results showed no significant differences between the three groups and there was even a trend towards the children with autism showing a slight superiority in relation to the other two groups in their ability to compute what a person was looking at.

Experiment 2 involved two tasks, one with upright faces and the other one with inverted faces. Subjects were required to choose which one of a pair of photographs presented simultaneously was looking directly at them. The reason for examining inverted faces was to test for differences between groups in the extent to which full face configuration, comprising features in their correct relative positions, is necessary for adequate performance on the task. Previous research with normal subjects has revealed that with deviations of 20, 10 and 5 degrees, only discriminations at 5 degrees are less accurately perceived when stimuli are inverted. Thus, for normal subjects, inverting the face impairs accuracy of gaze detection only when small angular deviations from the centre need to be discriminated (Campbell et al., 1990).

Based on the results from the previous two chapters and from other studies suggesting deviant patterns of eye gaze use, it could be predicted that individuals with autism would be impaired on the upright version of this task. However, evidence from other studies might indicate alternative predictions. For instance, there is some evidence to suggest that the eye direction detector (EDD) component of Baron-Cohen's (1995) ToMM is intact in individuals with autism (Baron-Cohen et al., 1995; Leekam et al., 1997). Baron-Cohen and colleagues devised a direction of gaze experiment using schematic faces. In this

experiment children with autism and two comparison groups of children matched for mental age were shown pictures of a cartoon face with eyes directed at one of four possible sweet bars. When normal or mentally retarded children were shown the picture and asked which sweet 'Charlie' prefers, they typically point to the sweet that the cartoon's gaze is directed towards. In contrast, the children with autism were significantly less likely to point to this particular sweet. They rule out the possibility that this deficit was due to an inability to perceive the direction of gaze based on the results of another task where the children with autism were able to select which of a pair of cartoon faces was looking at them. In other words, they were able to perceive the direction of gaze, but were unable to use such information to infer the mental state of another person. On this account, no differences between groups would be predicted on a task involving discriminations of eye gaze direction.

Moreover, other studies have suggested that individuals with autism may have an enhanced ability in making fine discriminations (Plaisted, O'Riordan & Baron-Cohen, 1998a; 1998b). Plaisted et al. (1998a) suggests that the superior performance shown among the high-functioning children with autism during a visual search task is consistent with the idea that unique item detection is enhanced in autism. They provide further evidence of enhanced discrimination of novel, highly similar stimuli in adults with autism during a perceptual learning task (Plaisted et al., 1998b). This raises the possibility that individuals with autism would show a superior performance to control subjects on this task, especially at the finer discriminations. Based on these conflicting studies, no a priori predictions were made about differences between the performance of individuals with autism and the comparison group.

8.2 METHOD – Study 5

Experiment 1: Control Task

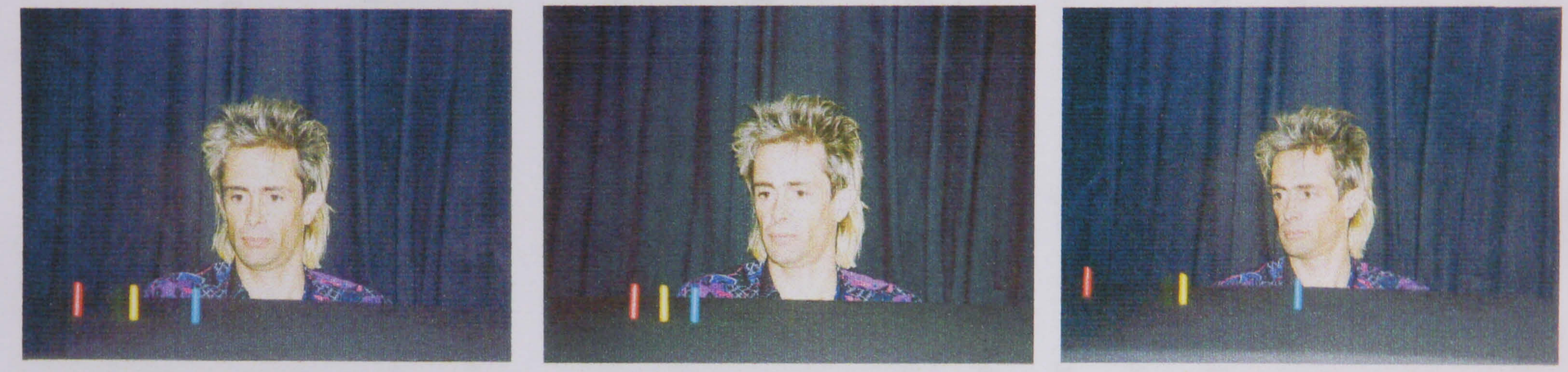
Participants

The same 16 participants from each group who took part in the previous congruent/incongruent gaze experiment were available for re-testing approximately one week later.

Stimuli and Apparatus

The stimuli were taken from a test devised by Perrett & Milders (1992), which comprised a set of photographs of a head looking at one of three coloured rods (red, yellow or blue). The participant is asked to identify which rod the person in the photo is looking at. The spacing between the three rods diminishes progressively as one works through the sequence from 20 degrees to 10 degrees to 5 degrees. The original set of photographs was prepared using a 35mm camera with 90mm lens. The rods were 4.5cm high. The yellow rod was always 20 degrees to the right of the stimulus head while the red and blue rods were always positioned at an angle respectively smaller and larger than 20 degrees. Degrees were measured from the stimulus head. The head was 53cm away from the rods and 280cm from the camera. In addition, both head orientation and eye direction were varied systematically at either 40 degrees, 30 degrees or 20 degrees and either matched or mismatched. This ensured that participants could not rely solely on either head orientation or the position of the iris within the sclera as the sole cue to identifying the task solution. The colour of the peg being looked at was also randomised so that three head orientations each with three possible eye orientations were tested. This yielded a total of 27 photographs measuring 9.5cm in height and 14cm in width. These images were scanned

and displayed using a PowerPoint presentation on a Texas Instruments Travelmate 6040 computer. Samples of the photographic stimuli are shown in Figure 8.1.



1 2 3

Figure 8.1. Examples of the experimental stimuli. In picture 1 the rods are separated by 10 degrees with head orientation at 20 degrees- correct response: Blue. In picture 2 the rods are separated by 5 degrees with head orientation at 30 degrees- correct response: Yellow. In picture 3 the rods are separated by 20 degrees with head orientation at 40 degrees- correct response: Red

Design

The experiment had a mixed design, with one between subject factor of group (Normal/Autism) and a within subject factor of Angular deviation (20,10 or 5 degrees).

Procedure

All participants completed this task prior to Experiment 2. Participants were told the following " a series of pictures of a man looking at one of three pegs will appear on the screen. You must (point to or) tell me the colour of the peg that you think he is looking at, red, blue or yellow". Participants were not given feedback nor allowed to review any of the images. Each participant was first asked a colour control question: "Can you show me the red/yellow/blue rod? None of the participants had any difficulty with this question.

8.3 RESULTS

The performance of the two groups is shown in Table. 8.1.

Table 8.1. Mean percent correct (out of 27) by each group.

		Mean % score
Normal	M	73.15
	SD	6.56
Autism	M	66.90
	SD	9.32

An Independent sample t-test revealed a significant difference between the two groups [t (30)=-2.19, $p<0.04$].

Figure 8.2 shows the relationship between accuracy and angular deviation of the pegs for both the group with autism and the comparison group. An ANOVA examined angular deviation as a factor affecting accuracy in both groups.

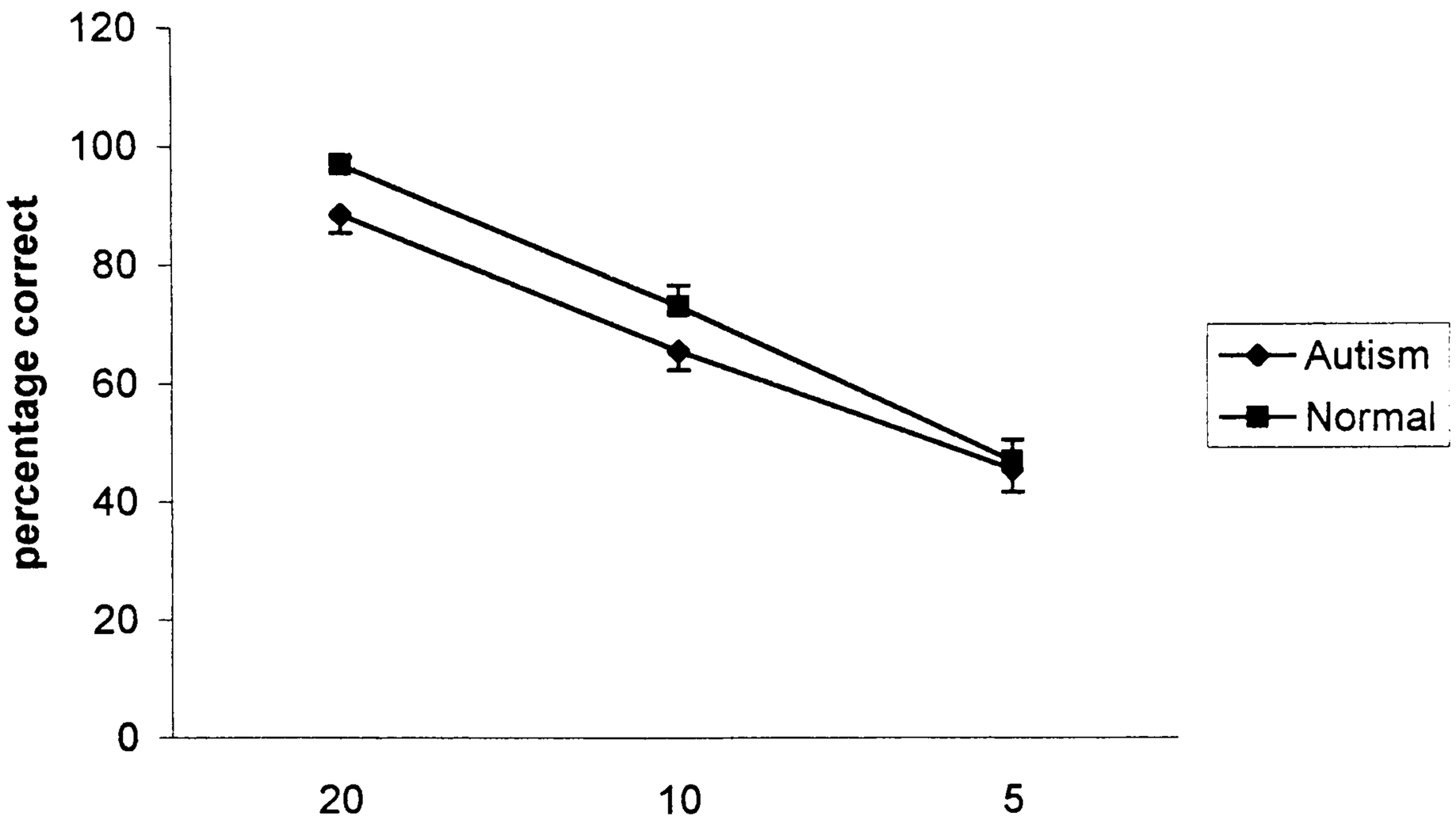


Figure 8.2. Mean % correct scores from each group as a function of the angular deviation between pegs.

This revealed a main effect of Angular deviation [F (2,60)=105.81, p<0.001] and a main effect of Group [F (1,30)=4.35, p<0.05]. There was no interaction between Group and Angular deviation [F (2,60)=0.72, p>0.05]. Although there was no interaction between Group and Angular deviation, for completeness, planned comparisons were conducted at each angular deviation. Independent sample t-tests at each degree revealed a significant difference at 20 degrees [t (30)=-2.42, p<0.02] but not at 10 degrees [t (30)=-1.59, p=0.12]

or 5 degrees [t (30)=-0.26, p=0.80]. Table 8.2 shows the mean (SD) percentage correct at each angular deviation for both groups.

Table 8.2. Mean (SD) percentage correct at each angular deviation for both groups.

		Mean % at 20	Mean % at 10	Mean % at 5
Normal	M	97.22	73.61	47.22
	SD	4.97	13.98	14.91
Autism	M	88.89	65.97	45.83
	SD	12.83	13.13	15.65

8.4 DISCUSSION

Experiment 1 was designed as a control task to avoid any criticism such as poor visual acuity, an inability to make fine discriminations or lack of social experience in making eye direction judgements contributing to any possible impairment in detecting direct gaze during Experiment 2. However, the results show that the individuals with autism were impaired on this task compared to control subjects. Planned comparisons showed that this difference was apparent at the easiest discrimination when the pegs were separated by 20 degrees. This result seems somewhat paradoxical, as although it was predicted that the group with autism would show no difficulties on this task, any possible impairments would be more likely at the hardest discrimination when the object is separated by another, by an angle of 5 degrees.

These results are also in marked contrast to those obtained by Leekam et al. (1997). Children with autism and two verbal mental age matched control groups performed a similar task where only two different degrees of separation were examined. The task

involved discriminations between coloured rods when they were separated by 20 and 10 degrees. While these authors report a comparable performance among the children with autism and the comparison groups in discriminating which rod the person was looking at, they note that many of the children with autism used a very concrete strategy of physically tracing their index finger from the stimulus head's eyes to the rod, a strategy not observed in the other two groups. While this strategy was not seen among the subjects with autism in this present study, it is possible that the degree of ambiguity between head orientation and eye gaze direction is greatest when the rods are spaced furthest apart, perhaps resulting in a reliance on head orientation among the group with autism to disambiguate where the eyes were directed.

8.5 METHOD

Experiment 2: Upright and inverted choice task

Participants

All participants from Experiment 1 completed Experiment 2 in one session.

Stimuli and Apparatus

The stimuli were identical to those used in an earlier study with prosopagnosic subjects (Campbell et al., 1990). The set of colour photographs were digitised and displayed using a PowerPoint presentation on a Texas Instruments Travelmate 6030 computer. The face was photographed in one of three different head orientations, 20 to the left or right or face on. For each position of the head the eyes could be in eight possible positions 2, 5, 10 or 20 degrees to the left or right. This resulted in a set of 24 stimuli. In addition, three identical sets of discriminanda were prepared where the head was in one of the three possible positions but the eyes looked directly at the observer. Each photograph was paired with the

appropriate direct gaze photograph and presented to subjects to 'choose the face that is looking straight at you'. The scanned photograph measured 7cm in height and 10.5cm in width. Participants responded verbally left or right and their response was recorded on a score sheet by the experimenter. All participants performed the task twice; once with correctly oriented faces, the other time with inverted face pairs. The order in which participants were presented with each task was alternated between successive participants.

Figure 8.3 shows an example of the experimental stimuli.

Figure 8.3 Sample pair of photographs used in the experiment. Subjects were required to choose the face on the right (eye -contact).

Design

The experiment had a mixed design, with one between subject factor of Group (Normal/Autism) and within subject factors of Orientation (upright/inverted) and Angular Deviation (20, 10, 5 and 2 degrees).

Procedure

Individuals were tested in an interview room at the participant's institution. The visual stimuli were presented on a computer monitor using a PowerPoint presentation, at a

viewing distance of 57cm and at a rate determined by the participants` response. Participants were told the following: "One of each pair of the pictures that you will see on the screen will be of a face looking directly at you. You must (point to or) tell me which face is looking directly at you, left or right". Participants were not given feedback and were not allowed to review the pictures.

8.6 RESULTS

Figure 8.4 shows the relationship between accuracy of forced choice detection of frontal eye gaze and angular deviation of the picture for both normal and individuals with autism viewing upright and inverted faces.

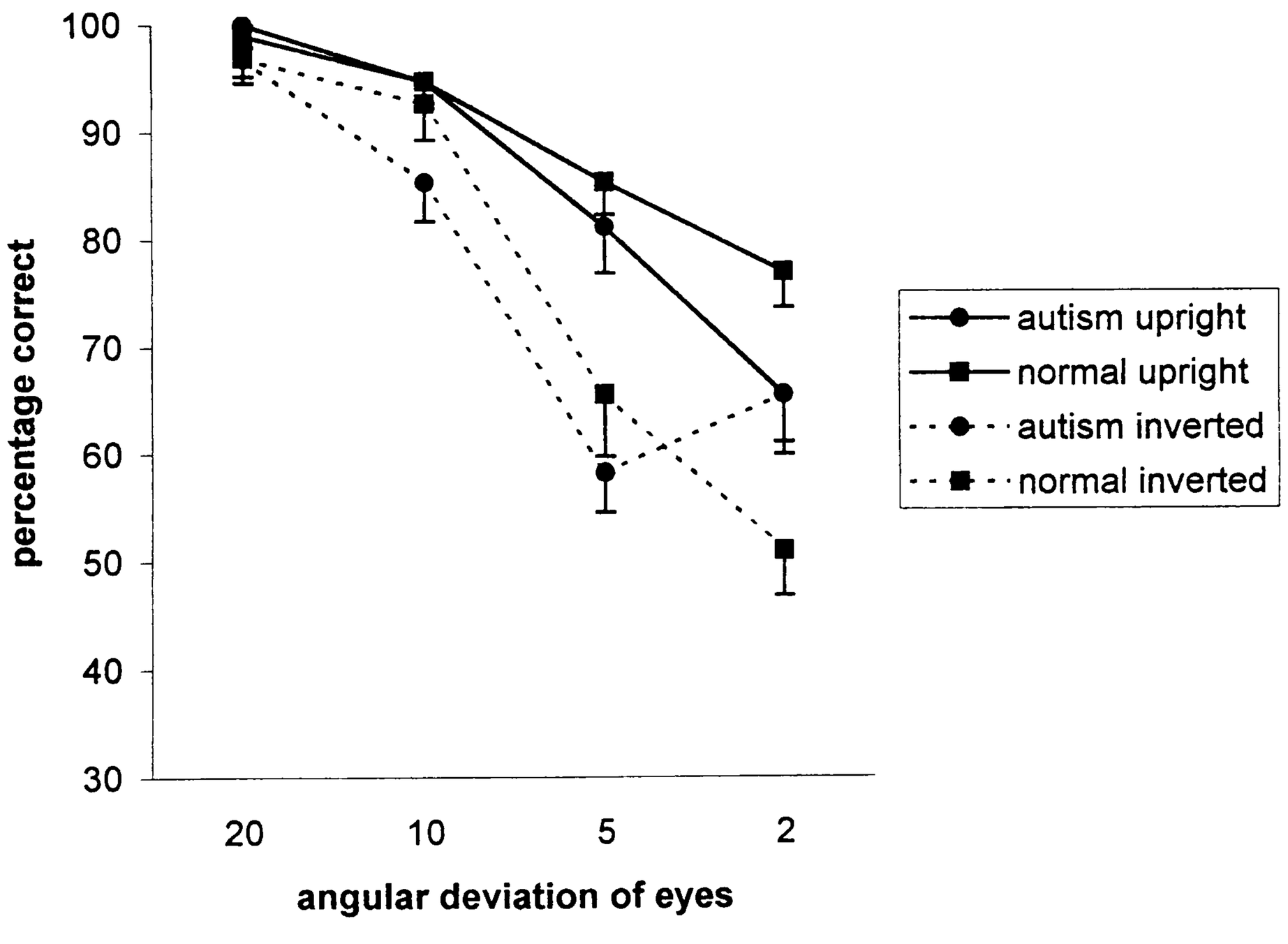


Figure 8.4. Mean % correct scores from both groups in both the upright and inverted choice task.

An ANOVA examined angular deviation and orientation as factors affecting accuracy in both groups of participants. An overall effect of Angular deviation was confirmed [F (3,90)=82.01, $p<0.001$], along with a main effect of Orientation [F (1,30)=40.48, $p<0.001$]. There was also an interaction between these factors [F (3,90)=7.60, $p<0.001$]. Simple effect tests showed that while deviation of 20 and 10 degrees were discriminated from frontal view at ceiling levels of accuracy ([F (1,30)<1], [F (1,30)=2.91, $p>0.05$]), deviations of 5 and 2 degrees from ahead were significantly less accurately reported [F(1,30)=40.47, $P<0.01$], [F(1,30)=15.05, $P<0.01$]. Similarly, there was a more significant effect of angular deviation in the inverted faces [F (3,90)=61.56, $p<0.01$] than the upright faces [F (3,90)=26.22, $p<0.01$]. There was no interaction between Orientation and Group [F (1,30)=1.18, $p>0.05$] or Angular deviation and Group [F (3,90) <1, ns] or main effect of Group [F (1,30)<1]. However there was a three way interaction between Orientation, Angular Deviation and Group [F(3,90)=6.26, $p<0.001$]. Simple effect tests revealed that the Orientation by Angular Deviation interaction was more significant for the normal control group [F (3,90)=8.25, $p<0.01$] than the group with autism [F (3,90)=5.62, $p<0.01$]. These tests also revealed that the effect of Orientation was not significant for angular deviations of 20 degrees [F (1,30)<1, ns], 10 degrees [F (1,30)=3.90, $p>0.05$ or 2 degrees [F (1,30)<1, ns] but was significant for 5 degrees [F (1,30)=23.31, $p<0.01$] for the individuals with autism. In contrast the normal control group showed a significant effect of Orientation at both 5 degrees [F (1,30)=17.38, $p<0.01$] and 2 degrees [F (1,30)=30.10, $p<0.01$] but not at 20 [F (1,30) <1, ns] or 10 degrees [F (1,30)<1, ns]. This suggests that the individuals with autism did not show a significant drop off in performance when the stimuli were inverted in the most difficult discrimination at an angular deviation of 2 degrees. Indeed, three individuals from the group with autism obtained 100% correct at

this discrimination, with 11 out of 16 of the participants performing at above chance levels. In contrast only 4 out of sixteen of the comparison group performed above the level of chance.

8.7 DISCUSSION Experiment 2

The results of Experiment 2 using upright stimuli indicate that the group with autism have no difficulty in judging when a person is looking at them. Both groups were sensitive to the degree of angular deviation from the frontal gaze position, showing a decrement in performance as the angular deviation of the eyes decreased. These results are in contrast to those of Howard et al. (2000) who used a reduced set of stimuli at deviations of 5, 10 and 20 degrees to investigate the perception of eye gaze direction in a group of high-functioning individuals with autism with enlarged amygdala volumes. These authors suggest that developmental malformation of the amygdala may underlie the social-cognitive impairments characteristic of high-functioning autism. The results suggested that the high-functioning individuals with autism were impaired in the perception of eye-gaze direction. There is contradictory evidence relating amygdala damage with difficulties in eye-gaze direction detection (Broks et al., 1998), however the contrasting results could be due to age of onset of amygdala damage. It is difficult to make direct comparisons between the results of the experiments reported in this chapter and those of Howard et al. (2000) to account for this discrepancy as exact figures were not reported for each angular deviation, nor whether the comparison group were performing at ceiling.

The results of the normal viewers in the inverted condition are concordant with those of Campbell et al. (1990) who showed that this task could be performed with upside-down faces, though with some loss of sensitivity for the smaller angular deviations of 5 and 2 degrees. The results of the group with autism in detecting direct gaze from inverted

stimuli also showed a decrease in performance with discriminations of 5 degrees, however there was no decrement in performance at the most difficult 2 degree discrimination. This indicates that while the group with autism are showing a comparable performance to the control group in angular deviations up to 5 degrees, the most difficult discrimination poses less of a problem for the individuals with autism. These results may suggest that the group with autism are achieving small discriminations in detecting eye gaze by different processes than the normal control group. This may also be related to the findings in Chapter 5 where inversion of the stimuli did not disrupt the cueing effects and to other research indicating a diminished disadvantage in processing inverted faces among individuals with autism (Langdell, 1978; Hobson et al., 1988).

It has been suggested that face perception is mediated by mechanisms that are different to those involved in the perception of objects (Farah, 1996). This dissociation is supported by evidence of the effects of face inversion in normal subjects (Valentine, 1988; Farah et al., 1998) and in patients with selective impairments of face and object recognition (Farah et al., 1995; Moscovitch, Winocur & Behrmann, 1997). In normal subjects, stimulus inversion is more detrimental to face recognition than to the recognition of other objects, suggesting that face recognition may be a specialised process that is more sensitive to stimulus orientation (Valentine, 1988). Moreover, in patients with prosopagnosia, the recognition of inverted faces can be relatively normal, indicating that upright faces may cause processing errors because of damaged face perception mechanisms which may interfere with processing by intact object perception processes.

On the other hand, inverted faces do not evoke processing by the damaged face processing mechanisms, thereby allowing intact object perception processes to operate without interference (Farah et al., 1995). Moscovitch and colleagues report evidence from a patient with object agnosia, whose face perception was normal, however recognition of

inverted faces was severely impaired. This suggests that intact face perception mechanisms by themselves cannot process inverted faces effectively. Indeed, Haxby et al. (1999) have shown in a study investigating face inversion using fMRI, that activation of face sensitive areas by inverted faces may reflect direct engagement of these areas, but that activation is insufficient to form a distinct representation of the individual shown. Consequently, the brain has to recruit additional processing resources elsewhere, namely in object selective regions to augment the distinctiveness of the representation of an inverted face. These resources may be related to features of object shape that are not as typical of faces.

Alternatively, the recruitment of these additional resources may reflect a different processing strategy, such as a change from a more holistic representation of a face to a representation based on a decomposition of the face into its individual parts (Farah et al., 1998).

It is therefore possible that individuals with autism do not have specialised brain areas devoted to the perception of faces, thereby causing no interference to object dedicated areas when the processing of inverted stimuli is required. Alternatively, as suggested by central coherence theory (Happé, 1994b), individuals with autism may prefer to adopt a local or relatively piecemeal processing style in deference to more holistic processing. They are therefore less likely to be disrupted by the inversion of faces as, although the processing of faces involves both featural (part) and configural (whole) processing (Tanaka & Farah, 1993), it appears that configural processing is interrupted by the inversion of faces.

8.8 GENERAL DISCUSSION

In summary, the results of the experiments reported in this chapter would indicate that the detection of frontal gaze appears to be intact in individuals with autism, suggesting that an

impairment in the detection of mutual gaze is not contributing to their difficulties in social interaction. There was however, some indication of peculiarities in face processing among the group with autism, in that they displayed no decrement in performance at the most difficult discrimination when the stimuli were inverted. It was suggested that this might indicate that individuals with autism are processing faces and detecting mutual gaze by different mechanisms than typically developing individuals. Therefore, it is also possible that differences in detecting mutual gaze may not become apparent in an unnatural experimental task such as this one, where the face stimuli are presented for as long as necessary. In the real world, faces and eye direction change at a fast face and must be integrated with other information and it is under these circumstances that differences may become apparent. A possible limitation of this study was the neglect of recording reaction time data. Alternatively, future research could investigate the detection of mutual gaze in more naturalistic settings with dynamic stimuli.

CHAPTER 9

General Discussion

9.1 INTRODUCTION

The main aim of this final chapter is to relate the implications of the results reported in the experimental chapters to theoretical issues raised in the introductory chapters. The Chapter begins with a brief summary of the main findings. Section 9.3 explores some possible limitations of the studies reported in this thesis. Following on from this, attention dysfunction and its relation to cerebellar pathology in autism are discussed in Section 9.4, in light of the results of experimental Chapters 3 and 4. The next section (9.5) highlights the role of inhibitory mechanisms and their possible involvement in the executive dysfunction theory of autism based on the results of Experiment 1 in Chapter 3. The experimental chapters on social perception and attention have both implications for 'Theory of mind' and 'Central coherence theory' and are discussed in Section 9.6. This discussion leads to consideration of the implications for modular mechanisms involved in social analysis in autism. Further avenues for future research concludes the thesis.

9.2 SUMMARY OF RESULTS

The first two experimental chapters investigated the performance of individuals with autism on two low-level tasks of attention. Chapter 3 considered the ability of individuals with autism to shift their attention both reflexively and voluntarily and found no pervasive deficits. While the results of the first experiment in Chapter 3 revealed that the individuals with autism were having some difficulty in reflexively shifting their attention in space at

short cue to target delays, this pattern of results was not replicated in Experiment 2. Voluntary attention shifting ability was explored in Experiment 3. Analyses designed to explore efficiency of attention deployment did not reveal a selective deficit in the individuals with autism compared with the matched control group. The task design also allowed the mechanism 'inhibition of return' to be explored. This mechanism, which is thought to be involved in the efficiency of visual search by producing a novelty bias, also appeared to be intact. Chapter 4 employed a standard visual search task. The results showed that while the group with autism were overall slower in responding, the pattern of results did not reveal any impairment in shifting attention. The remaining three experimental chapters investigated the response of individuals with autism to social stimuli. Chapter 6 investigated attention-shifting contingent upon social cues. No evidence of reflexive orienting in response to head orientation was found in either the individuals with autism or the control group. However, when instructed, both groups were able to use this type of social cue to direct their attention effectively. While both groups showed evidence of reflexive orienting to a change of eye gaze direction in another, the individuals with autism were less able to use this information voluntarily. This reflexive orienting was abolished by inversion of the stimuli in the comparison group, however this manipulation did not affect the results of the group with autism to the same degree. The experiments reported in Chapter 7 were designed to investigate the relative importance of eye gaze over head orientation in the analysis of social attention. While this issue remains unresolved, there were important differences highlighted between the two groups, with the group with autism again showing some difficulty in using eye gaze information. While this impairment may be contributing to their difficulties during social interaction, the experiments in Chapter 8 explored their ability to detect frontal eye gaze, which is also important during social interchanges. No significant differences were found between the

two groups in their ability to detect frontal gaze from upright stimuli. However the individuals with autism showed an enhanced ability at the most difficult discrimination when the face stimuli were inverted.

9.3 LIMITATIONS OF THE STUDIES REPORTED IN THE THESIS

The experimental studies reported in this thesis sought to clarify some of the methodological issues highlighted in other research into attention shifting in autism and contribute to the understanding of the problems with the analysis of social attention in individuals with autism. Although these aims have been met with some success, certain limitations of the studies must be recognised.

The first involves the choice of subjects. Only adolescents and young adults of relatively high ability participated in the experimental studies reported in this thesis. These results therefore, can say little about how learning-disabled individuals with autism would perform. Some attempt was made to recruit less able individuals, however it proved difficult to find subjects able to adhere to the experimental instructions across the large number of trials required to obtain an accurate reaction time. Furthermore, the age of subjects means that little can be said about how younger individuals might perform or about the developmental progression of abilities. This is a potentially interesting future line of enquiry.

A second possible limitation was in the design of the experiments reported in Chapter 3. More specifically, that the exogenous and endogenous shifting tasks in Chapter 3 were carried out in order rather than counterbalanced. This was mainly as a consequence of the results of one paradigm affecting the design of subsequent tasks. On the one hand, it could be argued that the order of experiments need not be counterbalanced as the inhibition effect and exogenous orienting occur quite automatically and without the need

for any deliberate strategy on the part of the subject (Posner & Cohen, 1984). On the other hand, the general finding that the group with autism are not impaired in their ability to orient attention either automatically or at will may be thrown into question due to possible carry-over effects. With hindsight, it would have been desirable to have counterbalanced the order of the three experiments reported in Chapter 3.

A third possible limitation surrounds the design of the studies reported in Chapter 6. Throughout the experimental studies there appeared to be a trend towards a general slowing of overall reaction time among the individuals with autism. However, with subsequent follow up experiments an amelioration in overall reaction time sometimes resulted in this group. Possible reasons for this phenomenon were explored, such as a general arousal and/or processing impairment (Ornitz & Ritvo, 1968). Alternatively, motivational and/or social factors such as a more general feeling at ease with the experimenter and the experimental procedure may have contributed to this effect.

In implementing the task design of the social cueing studies in Chapter 6, the question of whether to counterbalance the order of each set of experiments was considered in view of this amelioration in reaction time with subsequent similar tasks. It was decided that while it was necessary to counterbalance the order between participants within a set of experiments, participants should all complete the 'ignore' set with 50% probability first, followed by the 'attend to' cue set. While this again resulted in an amelioration of overall reaction time among the individuals with autism the main result of interest was the differences between invalid and valid reaction times and not to overall reaction time differences. This choice of order was further justified in light of the results of the two post hoc experiments designed to explore the possible confounding influence of the cue duration and SOA coinciding at 150ms, as the results showed that once you had been told

to attend to the cue this tendency was difficult to overcome with subsequent experiments where one was required to ignore the cue again.

A further possible limitation of the experimental studies reported in this thesis was the decision not to include a neutral cue in the social cueing studies reported in Chapter 6. As previously expressed in Chapter 3, efficiency of attentional deployment has often been examined by comparing the magnitude of the invalid-valid reaction time difference between each group, termed the validity effect. Alternatively, the cost-benefit analysis, originally developed by Posner and Snyder (1975) was designed to provide a more informative decomposition of reaction time with the consideration of a neutral cue. Both informative and neutral cues serve general warning functions. However, only the locational cue contains information that is relevant to the direction of attentional movements. Thus one should be able to attribute any difference in performance between neutral and informative cues to specific attentional processes.

However, it is clear that this rationale depends on the assumption that neutral and informative cues must be identical with respect to all their effects except that of information specific to the target (Jonides & Mack, 1984). For this reason, neutral cues should be physically similar, be interspersed randomly with informative cues, and occur with the same frequency. Moreover, these authors argue that an informative cue provides subjects with more information than a neutral cue, therefore it may well take more time to encode and extract this information, which may in turn influence reaction time to a target stimulus. In consideration of these warnings, the careful selection of neutral cues is required to avoid improper conclusions about the underling mechanisms that produce costs and benefits.

While the choice of neutral cues was not difficult in the cueing studies reported in Chapter 3 (two types of neutral cues were considered), choosing an appropriate neutral cue

for the social orienting studies was more problematic. During the design stage of the social cueing studies a photograph of a face with direct gaze was tried as a potential neutral cue. Traditionally, reaction times to neutral cues lie somewhere in the middle between a valid and invalid cue. However, this pilot work revealed that reaction time subsequent to a direct gaze was sometimes slower than an invalid gaze cue. There seemed to be something about a photograph of someone gazing directly at you that considerably slowed participant`s reaction time to targets. Moreover, it was not clear whether this would have been an equivalent neutral cue for the head orientation studies. For these reasons, the inclusion of this neutral cue was abandoned in the final experimental studies. However, with hindsight, it is possible that a photograph of a person with their eyes closed could have usefully served as a neutral cue.

It was also mentioned in Chapter 8 that a possible limitation of the gaze perception task was the neglect of recording reaction time. No differences between the two groups were found in the detection of mutual gaze with upright stimuli. It was postulated that as participants were given no time limitations for decision-making, group differences in relative efficiency at completing the task might have gone unnoticed. In the real world gaze shifts happen rapidly and unpredictably and it is possible that under time constraints, the group with autism may have shown impairments. While anecdotally there was no indication that the group with autism were taking an excessive amount of time in reaching a decision, an interpretation of any possible overall reaction time differences between the two groups would be problematic in light of the previous studies showing an overall slowing.

It is difficult to resolve the general finding that the group with autism took longer to respond in some of the reaction time tasks or the amelioration in reaction time with subsequent similar tasks given that all subjects did not participate in each experiment.

Moreover, a consideration of reaction time in both groups of subjects across experimental studies is problematic due to differing task demands in each study. While greater practice effects, social and/or motivational factors could account for the amelioration of reaction time with subsequent similar tasks found in the group with autism, other possibilities remain. For example, as considered in Chapter 3, theories that individuals with autism suffer from a deficit in their arousal regulation could account for these differences (Hutt et al., 1964, Dawson & Lewy, 1989).

Differing tasks demands to account for possible reaction time differences between groups was probed in Chapter 4 with a consideration of the performance on a binary versus a single choice paradigm. While these results suggested that an impaired ability to make and execute the appropriate response was contributing to the individuals with autism's visual search performance, a response selection impairment could only be part of the problem as the overall reaction time differences remained. Difficulties with perceptual grouping and strategy use were proposed as possible contenders. While it is conceivable that problems with perceptual grouping could account for impaired face processing during the social cueing studies, it is unclear how an impairment in strategy use would impair performance on simple cueing tasks

A more parsimonious explanation for overall reaction time differences may be to suggest that the individuals with autism have a more general processing impairment. This explanation also suffers from difficulties. Firstly, the subjects in the studies reported in this thesis were carefully matched with the control group on both verbal and non-verbal IQ. Moreover, while speed of processing and IQ are often linked (Sternberg, 1985) there was no correlation between reaction time and ability in the visual search tasks in either group. A further possible limitation was the neglect to undertake a simple reaction time task prior

to each experimental study to rule out or confirm a possible processing impairment explanation to account for any subsequent reaction time differences.

While these differences in overall reaction time seen between the two groups are interesting, the important findings in this thesis are the pattern of results and the differences between valid, invalid and neutral conditions. The implications of this pattern of results for psychological theories of autism and where future research might proceed will be discussed in the final sections of this Chapter.

9.4 IMPLICATIONS FOR AN ATTENTION DYSFUNCTION THEORY OF AUTISM

It was suggested in Chapter 1 that because attention plays an important role in the development of complex cognitive functions, an attentional deficit could produce severe developmental abnormality, perhaps resulting in the particular socio-cognitive functioning typical of autism. For example, in the individual with autism, attentional dysfunction may interfere with the ability to continuously follow the rapid changing events that compose reciprocal social interactions. An inability to selectively and rapidly shift attention contingent upon social signals may result in knowledge of the social world made up of disconnected fragments that lack context or temporal continuity. This would seriously hinder the individual with autism's ability to engage in joint social exchanges, which in turn could lead to deficiencies in social knowledge and communication. In addition to helping explain the principal social communication deficits in autism, an impairment in the control of attention may also be at the source of the other commonly observed abnormalities in autism, including stimulus overselectivity, uneven memory, insistence on sameness, perseveration, repetitive and ritualistic behaviours, narrowed interests and poor performance on executive function tasks requiring shifting of mental sets. The failure to attentively and completely explore in a timely fashion all elements of a complex stimulus array would result in an incomplete memory for events. What would be retained would not

necessarily be stimulus elements that had causal relationships with each other or spatial or temporal contiguity. Therefore the normal coherence of various elements of social and non-social events would be lost, as would the predictive correlations between them. Instead, unrelated fragments would be registered, possibly resulting in unusual associations and predictions about relationships. This could provoke disjointed and unexpected behavioural and emotional reactions by the individual with autism during interactions with the non-social and social environment. It is not difficult to understand why individuals with autism may prefer repetitive, predictable, invariant events over novelty, exploration and social exchanges.

The first aim of this thesis was to investigate the hypothesis that individuals with autism have difficulties in shifting attention (Courchesne et al., 1994). The results of Chapter 3 revealed no pervasive deficits among the high-functioning individuals with autism in either their voluntary or automatic allocation of attention. While the results of Chapter 4 revealed that the individuals with autism were slower to respond in a visual search task, the pattern of results was not suggestive of any attention shifting impairment.

Furthermore, one question that has been raised during the last three or four decades of research into autism is the role played by disturbances in the cerebellum in the symptomatology of this behavioural syndrome (Minshew, 1992). The current cerebellar model of autism hypothesises that a structural abnormality of cerebellar vermal lobules VI and VII is expressed functionally as a deficit in the capacity for shifting attention and is a primary cause of the behavioural abnormalities that define this syndrome (Courchesne et al., 1994). The results reported in this thesis provide no additional support for an attention shifting impairment hypothesis of autism.

However, it would be unwise to dismiss the idea of cerebellar abnormalities being involved in the symptoms found in autism because of this finding. To participate fully in

the real world requires the ability not only to shift attention through space but also through time. Ivry (1993) has proposed that the cerebellum operates as an internal timing system, invoked in both motor and non-motor tasks that require precise timing. Moreover, although the cerebellum has traditionally been viewed as essential for the control and integration of motor activity (Holmes, 1939: Hallett, Shahani & Young, 1975), recent years have seen claims that the cerebellum contributes to higher mental function (Leiner, Leiner & Dow, 1986, 1993; Bracke-Tolkmitt et al., 1989; Schmahmann, 1991; Canavan Akshoomoff & Courchesne, 1992; Kim, Ugurbil & Strick, 1994; Middleton & Strick, 1994, Sprengelmeyer, Deiner & Homberg, 1994; Gao et al., 1996).

Potentially fruitful lines of investigation could examine the performance of individuals with autism on tasks sensitive to cerebellar dysfunction. Indeed, a recent unpublished study (Neely, Turner & Findlay 2000) has made initial investigations into this area. The perceptual tasks employed in this study were adapted from a study by Ivry and Keele (1989) who investigated possible timing impairments in patients with cerebellar deficits. The first task measured subjects' ability to discriminate between small differences in the duration of two intervals. A control task was also used to test for generalised deficits in auditory perception. The subjects again heard two pairs of tones. However, the interval between both pairs was always 400ms, whereas the loudness of the second pair of tones was manipulated. No significant differences were observed between the group with autism and the matched comparison group on the loudness judgements. Although there was no significant difference in terms of sensitivity on the duration task, there were however, significant differences on a threshold measure, in that; the group with autism's point of subjective equality over-estimated the standard 400ms interval. At present it is difficult to interpret the behavioural ramifications of this result and there is certainly scope for further research into this area.

While several independent research groups have identified abnormalities of specific areas in the cerebellum (Courchesne, 1995; El-Badri & Lewis, 1993; McKelvey, Lambert, Mottson & Shevell, 1995), this may not be the primary underlying cause of autism. One problem in determining developmental brain damage is that it is difficult to ascertain which abnormalities are the primary root cause and which are subsequent consequences of earlier abnormal development. It is possible that the abnormalities sometimes observed in the cerebellum in autism are the consequence of a primary deficit elsewhere. Indeed these abnormalities may not be involved in any of the triad of impairments seen in autism. As the cerebellum has long been recognised as vitally important in regulating muscle tone, limb movements, timing of movement, speech, posture, balance and sensory modulation, perhaps the clinical observations of motor clumsiness especially among those who fulfil the criteria for Asperger's Syndrome may be explained (Attwood, 1998).

9.5 INHIBITORY MECHANISMS- IMPLICATIONS FOR EXECUTIVE DYSFUNCTION IN AUTISM

Frontal system models, developed during the last ten years have proposed deficits in executive function as the cognitive and neural basis of autism (Ozonoff et al., 1991). One aspect of executive function believed to be relatively spared in individuals with autism is inhibitory control of action. The first experiment in Chapter 3 was designed to investigate an additional low-level inhibitory mechanism, not previously explored, namely 'inhibition of return'. This basic inhibitory mechanism is thought to exert its effect by producing a novelty bias thus preventing perseverative types of errors. From the results reported in Chapter 3, it would appear that this mechanism is intact in individuals with autism,

providing further support for the notion that inhibition is not contributing to the deficits observed among individuals with autism on executive function tasks.

9.6 SOCIAL ATTENTION IN AUTISM

An alternative line of investigation, and the one pursued in the remaining chapters of this thesis was to examine attention-shifting contingent upon social cues. This line of investigation arose because of some of the questions raised in Chapter 5. Firstly, recent evidence from the joint attention literature in autism has proposed that orienting attention is only problematic when responding to social cues. Secondly, research from the visual attention literature has proposed that visuospatial orienting can arise in response to a 'social' cue in a reflexive manner in typically developing adults. Given the evidence that gaze processing is impaired at many different levels in autism, such as eye contact (Kanner, 1943), gaze following (Leekam et al., 1998) and joint attention (Charman et al., 1997), it was deemed important to investigate 'social orienting' in individuals with autism.

Social attention- implications for theory of mind in autism

The results of Chapter 6 revealed that individuals with autism displayed the same relatively automatic orienting response to the gaze direction of another as has been reported in typically developing adults. They were however, less able to use this 'social' information as effectively as the control subjects. It was postulated that there might be a developmental delay in acquiring this reflexive orienting response in individuals with autism resulting in a reduced ability to use eye gaze information effectively to guide their actions. This has some implications for Baron-Cohen's theory of an innate social module being specifically damaged in autism, as these results would suggest that some aspect of the SAM is intact or can be acquired at a later date.

An alternative view to the notion of a predetermined social module in the brain, advanced by Karmiloff-Smith and colleagues (1995), is that some degree of modularisation is the result of postnatal development, and not a precursor to it. Specifically, domain-specific biases in the newborn ensure that cortical circuits are preferentially exposed to socially relevant stimuli like language and faces. With prolonged exposure to such stimuli, brain circuits develop representations appropriate for processing these inputs, eventually giving rise to a super-ordinate system for the pragmatics of social interaction in general. In support of this account, there is evidence for a developmental progression in the ability to respond to social cues. Research with typically developing infants, has shown that in the second half of the first year infants begin to show the ability to look in the same direction as an adult's gaze and head turn. However, it is not until the age of twelve months that infants reliably look to where someone else is looking, regardless of whether a shift in gaze is accompanied by a head turn (Corkum & Moore, 1995). There is however, some recent evidence to suggest that infants as young as ten weeks old orient to gaze shifts alone (Hood, Willen & Driver, 1998).

In autism, perhaps the initial bias to attend to socially relevant stimuli such as faces and language is absent, resulting in less experience of complex interactions with other people which in turn affects the basic architecture of the cortex and relevant subcortical structures. On this account, individuals with autism may eventually develop an orienting response but with a slower time course than typically developing individuals, perhaps resulting in a reduced ability to use eye gaze information effectively.

Recent data may provide some support for the assumption of a developmental trend in responding to social cues and for the hypothesis that there may be a delay in autism. Swettenham, Milne, Plaisted, Campbell and Coleman (2000) have conducted a series of experiments investigating visual orienting in response to social stimuli in children with

autism. Children with autism (mean age 10.3 years) and typically developing children were assessed using a profile static and dynamic head cue. Typically developing children showed a significant cueing effect in both the static and dynamic cueing conditions, suggesting that they were reflexively cued by the head orientation. In contrast, the children with autism showed no validity effect in either the static or dynamic head cueing conditions, suggesting that they were not reflexively orienting to this social cue.

These results are not convergent with those reported in Chapter 5 where both the individuals with autism and the normal comparison group failed to show a reflexive orienting response to head orientation. However, it is possible that an early reflexive orienting response to the direction of another's head is replaced by an automatic tendency to respond to the gaze direction of another during development as one learns that in the analysis of social attention, the eyes are often more important.

However, there may be problems with the interpretation of the results obtained by Swettenham et al. (2000) as evidence for reflexive orienting. These authors report a cueing effect at both a SOA of 100 and 800ms in the comparison group. As mentioned in Chapter 2, one of the criteria for reflexive or relatively automatic processing is that it should develop quickly and be short lived. Therefore, one might expect the cueing effect to be present at the shorter SOA of 100ms and not at the longer SOA of 800ms. An alternative explanation for the results reported by Swettenham et al. (2000) might be to suggest that the children with autism were complying to the experimental instructions, whereas the typically developing children were not. This could be clarified by adopting slightly longer SOAs or a different range of SOAs.

Implications for central coherence theory

The difference in performance between the individuals with autism and the comparison group in the studies involving inverted stimuli was another significant result of interest. In Chapter 6 the orienting response to eye gaze was disrupted by inversion of the stimuli in the comparison group, however the group with autism were less affected by this manipulation. Furthermore, in Chapter 8, the group with autism showed no decrement in performance for inversion of the face stimuli at the hardest discrimination. It was suggested that this could provide additional support for the 'central coherence theory' of autism. It is possible that the individuals with autism adopted a more piecemeal style of processing in the analysis of the facial stimuli whereby they were less disrupted by inversion. Conversely, the typically developing comparison group adopted a more holistic processing style, which is more likely to be disrupted by this manipulation.

Implications for modular mechanisms involved in social analysis.

An alternative explanation proffered for the results was the possibility that individuals with autism may not have an intact face processing system, relying on object recognition systems instead. This may be related to the suggestion made above that lack of a pre-disposition to attend to social stimuli, alongside a dearth of experience in social interactions may affect the organisation of the cortex. Therefore, in individuals with autism, the processing of facial stimuli may be accomplished by a slower or more cumbersome object recognition system as opposed to one dedicated to the processing of faces.

9.7 FUTURE RESEARCH

The study of social attention in autism is a relatively new line of enquiry and there are a number of areas where future research could proceed. As discussed in section 9.6, a potentially fruitful line of investigation would be to examine the developmental progression of 'social orienting'. It was suggested that there may be a developmental sequence whereby an early appearing automatic or reflexive orienting response to the head direction of another is replaced by this same response to the eye gaze direction of another. It has yet to be established at what age might this occur in typically developing children and whether there is a delay in acquiring this response in individuals with autism. At present, there is tentative evidence that typically developing children orient their attention in a reflexive manner to the head direction of another at age 10, whereas this response is absent in children with autism at this age (Swettenham et al., 2000). To the best of my knowledge, no studies of orienting to the eye gaze direction of another have been conducted on children. Clarification of this issue could be gained by adopting the social cueing studies reported in Chapter 6 in either a longitudinal or cross sectional design.

Further investigation into the context effects of this orienting response may provide useful insight into the enigmatic results reported among the individuals with autism when processing inverted stimuli. For example, while it has been shown that typically developing individuals orient their attention in an automatic fashion to the gaze direction of a schematic face, it is not clear whether presentation of the eyes within the context of the whole face is necessary to elicit this response or whether subjects would respond in a similar manner to just a picture of the eyes. The results of Chapter 6 and 8 suggested that the individuals with autism were less disrupted by inversion of the stimuli. Proposals based on 'central coherence theory' argued that the individuals with autism were less impaired by this manipulation because they adopted a more piecemeal style of processing in

deference to processing in a more holistic fashion. Predictions based on this account would suggest that the context of a whole face would not be necessary to elicit an automatic orienting response in the individuals with autism, and just an isolated picture of the eyes would suffice. It could be however, that the eyes, seen in the whole context of a face would be necessary to produce an automatic orienting response in typically developing individuals.

While it was shown that individuals with autism were less able to use an eye gaze cue when instructed to do so, another line of investigation might be to examine the ability of individuals with autism to develop an expectancy from a social cue. Much of our perceptual effort is expended for good reason – so that we can operate on the world effectively. 'We perceive in order to act and we act to perceive' (Pick, 1992). If we consider inanimate objects as incapable of independent action, so that what they can do is influenced by what we can do to them, their characteristics can be predicted. It could be that because people are complex, novel and unpredictable, individuals with autism have difficulty in processing information of this nature. The child with autism's need for predictability has been noted in both clinical observations and anecdotal accounts and has also been demonstrated in experimental studies (Schopler, Brehm, Kinsbourne & Reichler, 1971; Clark & Rutter, 1981). This need for a highly structured routine and predictable environment persists for individuals with autism of all ages and functioning levels in contrast to many symptoms, which may attenuate with development (Turner, 1997). This may reflect a natural desire to anticipate regular events and therefore exert some sense of control over their environment.

Investigation into whether individuals with autism can develop an expectancy from a social cue could be achieved by manipulating the predictability of the cue without informing subjects of the probability contingencies and by comparing the invalid-valid

reaction time difference under the predictable and unpredictable conditions. If subjects can supplement exogenous orienting under the predictable condition with endogenous orienting, they should have larger validity effects or larger benefits and/or larger costs under the predictable condition than under the unpredictable condition. Studying this across development may also be interesting as a previous developmental study of covert orienting to peripheral visual cues has revealed that participants aged 6 and 8 were unable to take advantage of the predictability of the cue whereas adults aged 20 years were able to develop an expectancy in response to probability manipulations (Enns & Brodeur, 1989).

While the studies reported in this thesis examined two types of 'social' cue, social interactions are also accompanied by a myriad of gestures. Indeed, another way of directing someone's attention aside from a change in eye gaze direction or head orientation is to point. Furthermore, this so called 'protodeclarative' pointing is largely absent in young children with autism (Loveland & Landry, 1986; Landry & Loveland, 1988; Mundy et al., 1986; Sigman et al., 1986). One avenue of future investigation might be to examine whether pointing gestures also elicit an automatic orienting response in both typically developing individuals and among individuals with autism.

In all the cueing studies reported in this thesis, covert attention was examined. However, in the real world we usually move our eyes to the object of our attention. Relatively few studies have examined eye movements in individuals with autism and it may be of interest to investigate what aspects of scenes they pay attention to. One study has reported an abnormality in saccadic eye movements in terms of frequency in individuals with autism compared to typically developing and ADHD children (Kemner, Verbaten, Cuperus, Camfferman & Van Engeland, 1998). Another recent study by Minshew, Luna and Sweeney (1999) report oculomotor evidence for neocortical systems but not cerebellar dysfunction in autism. In this study eye movements were recorded

during three separate tasks, a visually guided saccade task, an antisaccade response suppression task and an occulomotor delayed-response task. No differences were reported for peak velocity, duration, latency or accuracy between the high-functioning adolescents and young adults with autism and a matched control group in the visually guided saccade task. However, the individuals with autism made more response suppression errors in the anti-saccade and the delayed response task. In addition the subjects with autism made more errors in their initial saccades and in the final resting position of their eyes to remembered target locations. These results suggest that it is volitional and not reflexive saccades that are impaired in individuals with autism. To provide a more ecologically valid regime, future research could investigate the scanning pattern of eye movements in individuals with autism when viewing everyday scenes and social situations to determine what aspects capture their attention and where they look for information.

9.8 CONCLUSIONS

It has been argued that an attention dysfunction is the primary cause of the symptomatology in autism (Courchesne et al., 1994). The experimental studies reported in this thesis provide no additional support for an attention shifting impairment hypothesis of autism. While a behavioural inhibition hypothesis has been proposed to account for repetitive behaviour in autism (Turner, 1997) and inhibitory mechanisms have been implicated as components involved in executive function tasks where individuals with autism perform poorly compared to matched controls, impairments have not been found on tasks designed to isolate low-level inhibitory mechanisms (Ozonoff et al., 1994; 1997). An additional inhibitory mechanism, not previously explored, namely 'inhibition of return' was investigated in this thesis. From the present results it would appear that this mechanism is intact in individuals with autism. The remaining experimental studies

investigated social attention and perception in autism. The results of these studies revealed that individuals with autism were able to use the larger and more salient head orientation cue to direct their attention. They did however, have difficulty in using information derived from the eyes, providing further support for the possibility that this impairment contributes to their difficulties during social interactions (Baron-Cohen et al., 1995; 1997).

Research into the analysis of social attention is a relatively new line of investigation, pursuit of which should contribute to the understanding of the difficulties experienced by individuals with autism in this area. While of obvious academic interest, the results of such research should also be informative to clinicians, carers and teachers, which could assist in the treatment and understanding of children and adults with autism. An increased understanding of the disorder is critical and should allow treatment to become increasingly specified and therefore, more effective.

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